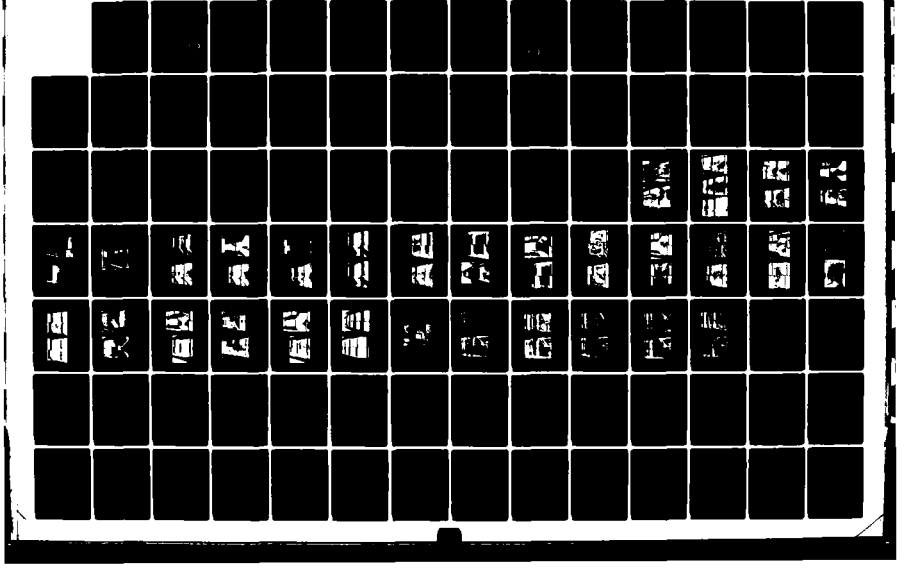
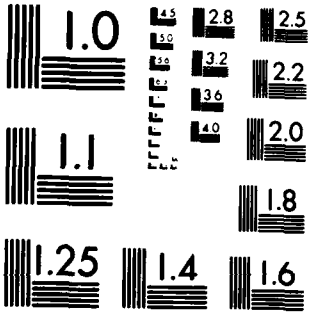
AD-A145 949 MODIFICATION OF FISH LADDERS AT JOHN DAY DAM COLUMBIA RIVER OREGON AND WA..(U) ARMY ENGINEER DIV NORTH PACIFIC BONNEVILLE OR DIV HYDRAULIC L.. P M SMITH

UNCLASSIFIED AUG 84 TR-103-2 F/G 20/4 NL

1/2





(2)

TECHNICAL REPORT NO.103-2

HYDRAULIC MODEL
INVESTIGATION

Modification of Fish Ladders at John Day Dam Columbia River, Oregon and Washington

SPONSORED BY
U. S. ARMY CORPS OF ENGINEERS
PORTLAND DISTRICT

CONDUCTED BY
DIVISION HYDRAULIC LABORATORY
U. S. ARMY CORPS OF ENGINEERS
NORTH PACIFIC DIVISION
BONNEVILLE, OREGON

AUGUST 1984

US Army Corps
of Engineers
Seattle District

T. R. 103-2

MODIFICATION OF FISH LADDERS AT JOHN DAY DAM, COLUMBIA RIVER, OREGON AND WASHINGTON

AUGUST, 1984

Destroy this report when no longer needed. Do not return
it to the originator.

The findings in this report are not to be construed as an official
Department of the Army position unless so designated
by other authorized documents.

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER Technical Report No. 103-2	2. GOVT ACCESSION NO. AD-A145949	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) MODIFICATIONS OF FISH LADDERS AT JOHN DAY DAM, COLUMBIA RIVER, OREGON AND WASHINGTON Hydraulic Model Investigation		5. TYPE OF REPORT & PERIOD COVERED Final Report 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s)		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Engineer Division, North Pacific Division Hydraulic Laboratory Bonneville, Oregon 97008		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Engineer District, Walla Walla Building 1602, City-County Airport Walla Walla, Washington 99362		12. REPORT DATE August 1984 13. NUMBER OF PAGES 117
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Hydraulic models
John Day Dam
Columbia River
Fish ladders

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Prototype operation of the originally constructed fish ladders at John Day Dam revealed the need for ladder modifications to improve fish passage. A 1:10-scale model was used to evaluate the design modifications for both the north- and south-shore ladders. Improvements were desired in the flow-regulating sections and at the fish counting station for both fish ladders. The model was instrumental in developing a successful modification to the Hell's Gate slot-orifice type regulating section. The modification consisted of a slot-only

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

design having a maximum head drop of approximately 6 inches. A vertical counting station was developed for the north-shore ladder. Successful operation in the prototype has verified the effectiveness of the design.

PREFACE

This report describes model studies made to develop modifications for the regulating section and counting stations of the fish ladders at John Day Dam. Model studies made to develop the original ladders are described in Technical Report No. 103-1, "Fish Ladders for John Day Dam, Columbia River, Oregon and Washington," dated December 1968.

Hydraulic model studies for the John Day project were authorized 14 July 1958 by the Office of Chief of Engineers, at the request of the U.S. Army Engineer District, Walla Walla, through the U.S. Army Engineer Division, North Pacific. The model tests reported here were conducted from September 1969 to October 1970 at the Division Hydraulic Laboratory, Bonneville, Oregon, under the general direction of the North Pacific Division Engineer.

Personnel of the Office of Chief of Engineers, North Pacific Division, and Portland and Walla Walla Districts visited the Laboratory to observe the model tests and discuss the results. Flow conditions in the model were demonstrated for representatives of the U.S. Fish and Wildlife Service and the fish and game departments of Oregon, Washington, and Idaho. Tests of the regulating sections were coordinated with full-scale tests of parts of the same sections conducted at the Fisheries-Engineering Research Laboratory (FERL), National Marine Fisheries Service, North Bonneville, Washington.

The studies were conducted by Mr. D.E. Fox under the supervision of Messrs. P.M. Smith and A.J. Chanda, Chiefs of Structures Section and Hydraulics Branch, respectively, and H.P. Theus, Director. This report was prepared by Mr. Smith.

TABLE OF CONTENTS

CONVERSION FACTORS, U.S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U.S. Customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
feet	0.3048	metres
miles (U.S. statute)	1.609344	kilometres
square feet	0.092903	square metres
feet per second	0.3048	metres per second
feet per minute	0.3048	metres per minute
cubic feet per second	0.0283168	cubic metres per second

MODIFICATION OF FISH LADDERS AT JOHN DAY DAM
COLUMBIA RIVER, OREGON AND WASHINGTON
Hydraulic Model Investigations
PART I: INTRODUCTION
The Prototype

1. John Day Dam is a multipurpose project located on the Columbia River about 25 miles* upstream from the city of The Dalles, Oregon, at the head of the reservoir of The Dalles Dam (figure 1). The reservoir extends slack water navigation upstream 77 miles to McNary Dam and provides 500,000 acre-feet of storage for flood control between pool elevations 257 and 268**. The project has a 20-bay spillway (design discharge 2,250,000 cfs), a 20-unit powerhouse (ultimate capacity 2,700,000 kilowatts), a single-lift navigation lock having clear dimensions of 86 by 675 feet with a maximum lift of 113 feet, and facilities for passing migratory fish upstream over the dam (plate 1). Additional details of the project, especially the fish facilities, are given in Technical Report No. 103-1.

2. The fish facilities include two fish ladders--one near each end of the dam--to pass the fish migrating on both sides of the river (plate 1). Each ladder has a sloping section of cascading pools, a flow regulating section, and a fish-counting and identification station. The sloping section is a series of 10-foot-long by 24-foot-wide pools separated by vertical weirs having overflow notches at each end and an orifice opening on the floor beneath each overflow. Another orifice is provided on the

---

* A table of factors for converting British unit of measurement to metric units is presented on page iii.

** Elevations are in feet above mean sea level.

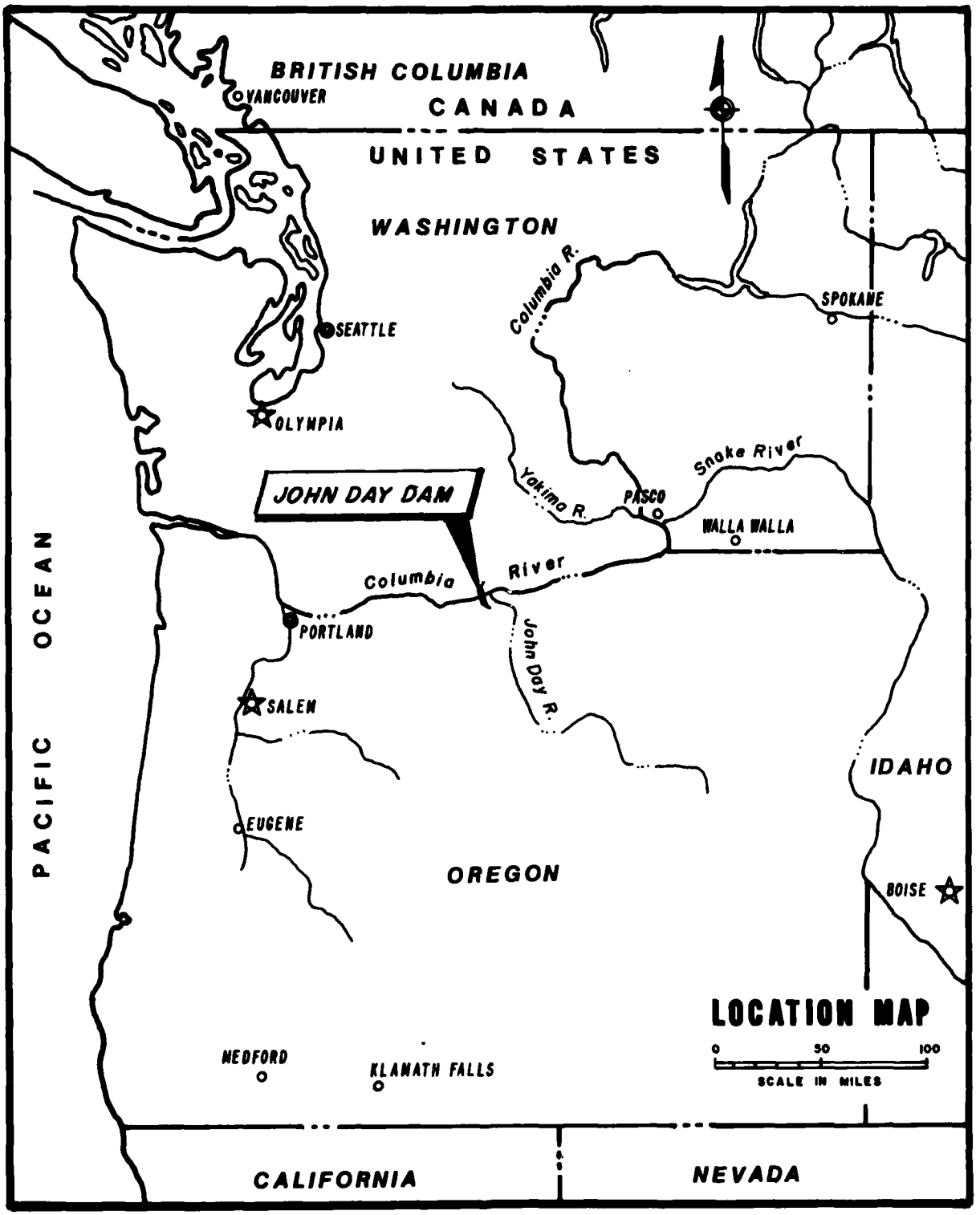

BRITISH COLUMBIA
VANCOUVER
CANADA
UNITED STATES
WASHINGTON
Columbia R.
SPOKANE
SEATTLE
OLYMPIA
JOHN DAY DAM
Yakima R.
PASCO
Snake River
WALLA WALLA
Columbia River
PORTLAND
John Day R.
SALEM
IDAHO
EUGENE
OREGON
BOISE
PACIFIC OCEAN
LOCATION MAP
0 50 100
SCALE IN MILES
MEDFORD
KLAMATH FALLS
CALIFORNIA
NEVADA

Figure 1

floor at the center of each weir. The center orifices are closed but can be opened if the need for additional passage area is indicated.

3. Initially the regulating section consisted of 19 nonoverflow bulkheads with orifices. As the forebay pool fluctuated, the section passed 50 to 90 percent of the discharge required for the sloping section, and the remaining water required to maintain a constant discharge was supplied through a floor diffuser at the downstream end of the regulating section. Each bulkhead of the regulating section had a submerged orifice near each wall. All but two of the bulkheads had a third, higher orifice at the center that operated under shallow submergence to aid the passage of shallow-swimming fish such as shad and sockeye or blueback salmon. The counting station of the north shore ladder was an older-style station with a shallow horizontal counting board viewed from above the water surface. The station was located between the floor diffuser at the downstream end of the regulating section and the top weir of the sloping section. The counting station of the south shore ladder was a newer style with a vertical counting board extended from the surface to 2 feet above the bottom and viewed through a submerged window. The station was located within the sloping section between weirs 193 and 194.

Need for Model Studies

4. After the first year of ladder operation, several fish-passage problems were apparent. The shallow-swimming fish-- particularly the shad--were reluctant to pass through the regulating sections. Although the high center orifices had been installed in the bulkheads for the shallow swimmers, only a limited number of fish were attracted to them. Before the second year of operation, the shallow orifices of the north shore regulating section were enlarged to provide free-surface flow. Fish passage was

improved, but further improvement was needed. At the north shore counting station, all species of fish were reluctant to pass over the counting board. Of those that did pass over, many milled in the diffuser pool just upstream and were reluctant to enter the regulating section. Visibility for counting with the horizontal counting board was reduced by surface disturbances and light reflection. At the south shore counting station many shad milled in the pool upstream from the counting board where upstream surface flow led the shad away from the narrow overflows at the ends of weir 194. In addition, fish identification at the south shore counting board was hampered by fine bubbles entrained in the outflow of weir 194 and carried through the counting channel.

5. Model studies of the regulating sections and the counting stations were made to develop revised designs that would create hydraulic flow conditions conducive to the passage without delay of all species. Special emphasis was placed on developing flow conditions for easy, continuous passage of shad. Two of the regulating section designs developed were studied further in full-size models at the FERL at Bonneville Dam by the National Marine Fisheries Service to evaluate fish passage.

PART II: THE MODEL

Description

6. Initially the 1:10-scale model reproduced the upstream nine pools of the sloping section of the ladder, the counting station, the regulating section, the exit channel through the dam, and a small section of forebay of the north shore ladder. Following development of the north shore regulating-section and counting-station designs, the model was modified to reproduce both the south shore regulating section with exit channel and forebay and the south shore counting station with adjacent pools of the sloping section.

Facilities

7. Water used in the model was recirculated by a pump, and the discharge was measured with a V-notch weir. Velocities were measured with a midget current meter having a horizontal axis. Water surface elevations were measured with piezometers and electronic point gages in stilling wells, and depths were measured with staff gages. Tailwater elevations were controlled by adjustable tailgates.

Scale Relationships

8. Model measurements were converted to prototype values using equations of similitude based on the Froude model law. The following model-to-prototype data equivalents were used:

Characteristic	Dimension	Model: Prototype
Length	L_r	1:10
Area	$A_r = L_r^{2}$	1:100
Velocity	$V_r = L_r^{1/2}$	1:3.16
Discharge	$Q_r = L_r^{5/2}$	1:316.23
Pressure	$P_r = L_r$	1:10

PART III: TESTS AND RESULTS

North Shore Regulating Section

Plan A

9. The Plan A regulating section was a slot-orifice type similar to that developed for Lower Granite Dam (plate 2). The section had 19 pools to control flow with a forebay fluctuation of 11 feet. Pools were separated by non-overflow baffles, each having a deep, narrow slot and a deep, submerged orifice (photograph 1). The drops in water surface from pool to pool were to be approximately equal with an average maximum drop of 1.0 foot and a minimum drop of 0.5 foot. Nineteen pools were required to meet the criteria with the maximum forebay but this number was excessive with the minimum forebay. With low forebay levels, the head drop criteria could be met by diverting flow around the seven upstream baffles and through the bypass channel adjacent to them. When not in use, the channel was bulkheaded at the upstream end and fish entry was blocked by a screen at the downstream end (photograph 1).

10. Flow conditions in the Plan A pools were not satisfactory, and the drops in head varied from 0.85 to 1.14 feet with maximum forebay and from 0.31 to 0.92 feet with minimum forebay. The need for modification of pool shape to create a better flow pattern and of slot sizes to create a more uniform head drop was indicated. With a high forebay, the slot flow short-circuited across all the pools and utilized less than half of the pool volume for fish passage and efficient energy dissipation (photograph 2). The orifice flow impacted against the downstream baffle and caused a boil that would attract shad and other shallow swimmers into a dead end corner. A very turbulent eddy occurred in the upstream right corner of the pools adjacent to the slot inflow, and a vertical upwelling occurred along the face of the left panel of the upstream baffles. The upwelling would attract shallow-swimming

fish to the baffle rather than to the slot. Outflow from the downstream slot (baffle 249) was a concentrated jet that extended into the counting station (photograph 2). With low forebay levels, the flow pattern was satisfactory and the bypass channel functioned as designed. When the channel was open and baffles 261 to 267 were not in use, the right half of pool 260 at the downstream end of the channel had a large low-velocity eddy that might be a milling area for shad. Closing the orifices eliminated the boil created by the orifice jets; however, the drop in head from pool to pool with the maximum forebay increased to a variation of 0.83 to 1.33 feet. A large 45-degree fillet in the upstream right corner of pools 250 through 259 eliminated the eddy in that corner and directed the slot jets along the walls of the right side of the pools.

Plan B

11. The Plan B design (plate 3) increased the size of all slots except for slot 267. Large 45-degree fillets were added to the upstream right corners of pools 249 through 259. The slots in baffles 261 through 267 were moved to the left side, and the orifices were moved to the right side. The two baffles in the exit channel through the non-overflow dam were changed to single slot baffles. Baffle 249 was changed from a slot-orifice design to a modification of the existing orifice design.

12. Flow conditions improved with Plan B but were still not fully satisfactory (photograph 3). In general, flow was satisfactory in the pools downstream from the bypass but not in the pools adjacent to the bypass. The large 45-degree fillets in pools 250 through 259 were effective in eliminating the eddy in that corner and initiating an S-pattern of flow that utilized most of the pool. In the other pools in which such a fillet would have blocked the orifice, the slot flow short-circuited across the pools as in

Plan A. At the downstream wall of the pools the orifice flow caused intermittent boils which were considered acceptable but not desirable. The single slots in baffles 268 and 269 in the exit channel along with a wall deflector downstream from the baffles created a more distinct attraction flow in the channel. Outflow of baffle 249 was also improved. Surface flow attraction was created along both walls of the counting station exit pool from the baffle to the counting channel. The drops in head were more nearly uniform with the revised slot sizes.

Plan C

13. The bypass of baffles 261 through 267 in Plans A and B was hydraulically satisfactory; however, a simpler, more automatic means of operation with low forebays was desirable because of operational problems such as clearing fish from the bypass during closure of the bypass. This was achieved in Plan C with full-width baffles throughout the section and removable sills in the slots of baffles 263 through 267. The sills were designed to be out of the flow with forebay elevation 257 through 262. Baffle 249 was the same as in Plan B except that the top left orifice, which functioned as a weir, was reproportioned. Baffles 250 through 267 were the same as the slot-orifice baffles 250 through 260 of Plan B. The slot widths and sill heights were adjusted to produce nearly uniform head drops with maximum forebay pool. Baffles 268 and 269 in the exit channel were unchanged from Plan B. Details of Plan C are shown in photograph 4 and on plate 4.

14. Plan C functioned satisfactorily in the model, but the right side of the pools was very turbulent with the higher forebays (photograph 5). The turbulence and, according to some observers, the 8- to 9-fps velocities at the slots with the 1-foot drops in head were thought to be excessive for easy passage of

shad. However, tests of six full-scale pools in the FERL showed that shad and salmonoids would pass through the pools without delay or difficulty.

15. The slot-orifice flow of Plan C created head drops varying from 0.04 to 1.04 feet, which were considered acceptable because strong flow patterns occurred in all pools and energy carry-through produced accompanying slot velocities of 2.1 to 8.4 fps (table A and plates 5A through 6B). The regulating section discharge varied from 18.9 to 85.0 cfs. These discharges were 23 to 103 percent of the desired ladder discharge for a 12-inch head on the weirs (82.2 cfs) and were also considered acceptable. The maximum discharge would create a head of 12.8 inches on the ladder weirs. The removable sills functioned well. Flow conditions were good with the removable sills either in or out with a changeover at forebay elevation 261 to 263 (plate 6A and 6B and tables A and B).

16. Although the orifice flow of Plan C did not appear objectionable in the 1:10-scale model, full-scale model tests at the FERL revealed that with all of the orifices located on the floor, the orifice jets switched back and forth and from side to side causing intermittent boiling at the next downstream baffle. Due to this condition, tests with the orifices closed were made at both laboratories. The flow condition in the model with the orifices closed (slot flow only) is shown in photograph 6, and flow data are given in table B and on plates 7A through 8B. In general, flow conditions were similar to those with slot and orifice flow. With slot flow only, ladder discharges decreased and most slot velocities were slightly lower. Drops in head varied from 0.04 to 1.06 feet with accompanying slot velocities of 1.9 to 8.3 fps. Discharges varied from 16.3 to 72.4 cfs—20 to 88 percent of the ladder discharge for a 12-inch head on the weirs. Turbulence in the right side of the pools was about the same as occurred with

the orifices open. With the maximum forebay and slot flow only, a boil occurred in the upstream left corner of pool 263 (plate 7A). A rolling flow occurred in that corner of the other pools (photograph 6). In the FERL tests with slot flow only, shad and salmon passed through the full-scale pools without difficulty or delay. Representatives of the Corps and the fisheries agencies verbally concurred that the degree of acceptance by shad would determine the acceptability of the design; by this criterion Plan C was acceptable.

17. Due to turbulence and the objection of some to slot velocities of 8 fps, other improvement of flow condition with Plan C besides elimination of orifice flow was sought. When the orifices were closed, removal of the 18-inch fins near the orifices caused a slightly improved and less turbulent flow pattern in the left side of the pools (photograph 7 and plate 9). Also, narrowing the pools by moving the left wall nearer the slot decreased the size of the large eddy in the left side of the pools and caused a more distant flow path to develop. The rolling flow along the left side of the upstream wall was greatly reduced and velocities increased because of the loss of dissipation area. Flow conditions improved as the pools were narrowed until the walls were moved in approximately 8 feet. With pools narrower than 8 feet, boiling occurred along the left wall. The improvement did not appear to warrant the cost of narrowing the existing prototype ladder section. Large fillets in the corners of the walls also caused a slight, but not significant, improvement of flow conditions.

Plan D

18. In attempting to develop better flow conditions, simpler pool shapes designed for less head drop were studied. Details of typical parts of Plan D as tested in preliminary studies are shown

on plate 10. The pool length was shortened from 16 to 10 feet to permit additional pools to be located in the available space subsequently lowering the maximum drop in head to 8 inches per pool. The Hell's Gate slot and baffles used in earlier plans were replaced with a simple slot perpendicular to the ladder centerline to utilize the width of the ladder for energy dissipation of the slot flow and a wall baffle to train the flow into an S-pattern in the pool. In preliminary tests with pools of shallow and medium depths, the flow conditions were good (plate 11); however, in the deep pools having higher sills some instability of flow pattern occurred with the larger drops in head (6 to 8 inches). To stabilize the flow, fillets were required in all four corners of those pools and orifices were required in the high sills to introduce flow to the lower portion of the pools. With low head drops, the S-pattern did not form in the deeper pools and there was no distinct attraction path through the pools. Slotted longitudinal (parallel with flow) baffle walls, extending across the pools between the slots in the lateral baffles (photograph 8), were required to maintain a desirable flow pattern with all flows (2- to 8-inch drops in head). Further development of Plan D was halted in favor of a new design--Plan E.

Plan E, Final Design

19. Plan E was the result of a progressive change in pool shape and flow criteria from the Hell's Gate type slot-orifice baffle, with a maximum head drop of 1 foot and a low-flow bypass, to a simpler slot baffle with a maximum average drop in head of 6 inches and removable sills. To permit regulation with the full 11 feet of forebay fluctuation with a maximum drop of 6 inches, the number of typical pools was increased to 34 and their size was decreased to approximately 11 by 15 feet. A minimum distance of 6 feet was maintained from corners to center of slots to assure adequate alignment space for large fish. The two pools and baffles

268 and 269 in the exit channel were the same as those in Plan C. The orifices in the Plan C baffle 249 at the downstream end of the regulating section were modified for Plan D by closing the bottom center orifice and replacing the two top orifices with three orifices which operated as shallow slots. The two 1.5-foot fins on the upstream face of the baffle were replaced by a single fin on the right side. Details are shown in photograph 9 and on plate 12.

20. Flow conditions with Plan E were satisfactory in the model and in 10 full-scale pools tested concurrently at the FERL. A consistent, distinct, and continuous attraction path was formed by the S-pattern flow in pool 249, along the walls from slot to slot in pools 1 to 34, and from slot to slot in the exit channel. This flow in the model and the same attraction flow along the walls in full-scale pools 1 and 2 observed at the FERL are shown in photograph 10. Slot velocities and minimum depths at the slots observed in the model are listed in tables C and D; velocities and flow directions are shown on plates 13A through 15. Due to the superelevated water surface caused by the circular flow pattern in the pools, a representative water surface in the pools from which to compute head drops could not be easily obtained. Since velocity created by the head drop was the significant criterion, slot velocities were substituted for head drops as an indicator of uniform flow conditions from pool to pool and of conditions within acceptable limits. The desired maximum average head drop of 6 inches was represented by a theoretical slot velocity of 5.7 fps and, with energy carry-through, by a slot velocity of approximately 7.0 fps.

21. With forebay elevation 268--the maximum and design forebay pool--velocities at slots 1 to 35 varied from 5.8 to 6.9 fps and those at the three slots of baffle 249 varied from 5.1 to 6.6 fps. The velocities were acceptable in magnitude and uniformity. The velocities at slots 268 and 269 were 4.6 and 4.0 fps, respectively,

and carried through the exit channel sufficiently to create a distinct attraction path from slot 35 to the forebay. The velocities were not uniform with other forebay levels within this operating range but had an acceptable magnitude (table C). Operation was satisfactory both with and without the removable sills in place with forebay levels 1 foot above and below the changeover elevation of 262. With all operating conditions the minimum passage depth was greater than 3 feet (table D). The regulating section discharge varied from 20.0 to 70.2 cfs--24 to 86 percent of the total ladder discharge.

22. Fillets were required in certain corners to help turn the flow and to prevent boiling or excessive rolling of the flow. The need for the fillets (plate 12) was determined by observation in the model. Afterwards, fillets of the same size were desired in all corners for structural reasons. Tests showed that such fillets were satisfactory and perhaps improved flow conditions slightly. No noticeable change in slot velocities was found to occur; however, the overall increase in flow efficiency resulted in a 2½-percent increase in discharge (from 70.2 to 72.0 cfs) with maximum forebay elevation 268.

23. In order to facilitate shad passage, special attention was given to flow in the right downstream corner of pool 35 at the entrance to the exit channel. With higher discharges and deeper flows, the flow moved to the corner of the surface and out along the bottom; with lower discharges a large eddy formed. In either case, shad that entered the area would be attracted out to the main flow stream from slot 268 to the left wall of the pool (photograph 10 and plates 13A through 15).

24. Two other special items were also studied--use of the existing fins on baffle 249 and larger bevels on the edges of the slots. The existing fins on baffle 249 were not satisfactory.

Flow buildup occurred on the left side of each fin causing excessive outflow from the left slot and interference with the S-pattern of flow through the pool (photograph 11). The new single fin near the third point of the weir was needed to stabilize the S-pattern (photograph 10). Bevels 3 or 6 inches long were not needed in place of the standard 3/4-inch bevels on the edges of the slots. In the even-numbered pools, flow conditions were the same with all bevel sizes. In the odd-numbered pools, the eddy was slightly less stable with the 3- or 6-inch bevels. Flow conditions with the 6-inch bevels are shown on plate 16.

North Shore Counting Station

Plan A

25. The counting station in the north shore fish ladder was located at the top of the sloping ladder section and immediately downstream from the regulating section. The existing station, which had a shallow horizontal counting board and viewing from above the water, was to be replaced with one having a vertical counting board and underwater viewing. The new counting station, which was to be similar to that in the south shore ladder, was to provide a greater range of depth for fish passage and better viewing for counting. Details of the initially proposed design are shown on plate 16. After construction of the model, the proposed width of the counting channel was reduced from 4 to 3 feet. This change was simulated in the model by setting the adjustable counting board at a maximum opening of 3 feet as shown on plate 17. Because the station was to be built a year before the revised regulating section, initial studies were made with the existing regulating section (partially shown on plate 17). Afterwards the station was studied with the different plans as the revised regulating section was developed. The studies were principally concerned with flow conditions for good fish attraction and passage

upstream and downstream of the counting board, self cleaning of the trash rack, and flow conditions upstream of the board for minimum flow of air bubbles across the board. Good self cleaning of the rack was especially desirable near the water surface where weak shad might become trapped against the rack by the flow.

26. Observations of the self-cleaning characteristics of the trashrack with three vane alignments are listed in table E. Vanes aligned 90 degrees to the flow were the best, especially when all the flow for the sloping ladder was introduced through the regulating section (maximum normal forebay). Vanes set 45 degrees to the flow were almost as effective as the perpendicular vane. Vanes parallel to the flow performed poorly. Larger discharges through the regulating section caused more turbulence at the rack and aided self cleaning. Throttling of the regulating gate to create greater head drop across the counting board also aided self cleaning--less flow passed through the rack and more flow swept across the rack to the counting channel. None of the alignments readily shed debris with the minimum forebay conditions (diffuser discharge of 37 cfs).

27. The flow patterns and velocities in the counting station for the extreme operating conditions of maximum and minimum (zero) diffuser flow, 3-inch and minimum head drop across the counting board, and maximum (36-inch) and minimum (9-inch) board opening are shown on plates 18 through 21 with the trashrack vanes 90 degrees to the flow. The velocities were acceptable for fish attraction and passage for all conditions, but the flow patterns were not acceptable. With all conditions tested, an eddy with horizontal and vertical flow directions occurred on the right side of the section in the square corner formed by the upstream side of the counting house. The eddy, which could have been a milling area for shad, was eliminated by blocking off the corner with a diagonal wall (plate 22). An eddy also occurred along the diagonal wall downstream from the counting house. Although downstream flow

along the wall was preferable, the low-velocity return flow was not considered objectionable. Good attraction flow to the counting board existed along the edge of the eddy. The flow pattern along the fish guides downstream from the counting board was generally good; however, with the minimum head drop condition across the counting board, reverse flow existed at the very upstream end of the guides at forebay elevation 265 (plates 23 and 24). When the regulating gate was throttled to create a head drop of 2 inches across the counting board, flow was into--rather than out of--most of the guides. Deflectors in the bypass flow area on both sides of the regulating gate eliminated the reverse flow at the upstream end of the guides with forebay elevation 265 but had little affect on the reverse flow when the gate was throttled (plate 25). Setting the trashrack vanes at 45 degrees to the flow had the same effect as the deflectors (plate 26). As on the other side by the diagonal wall, the desired flow conditions along the guides were not obtained with all operating conditons but were considered acceptable. When an eddy formed along the guides, the velocities in it were low and good attraction flow to the counting board occurred along the edge of the guide. The top orifices of baffle 249, which were upstream from the counting station, functioned as weirs with the surface outflow entraining air. Although this model did not reproduce bubble flow to scale, the surface turbulence of the outflow in the model indicated that the entrained air would be carried through the short diffuser pool and to the counting channel. The bubbles were not desirable because they would interfere with counting.

28. Along with the development of the new regulating section, changes were made in the design of the vertical counting station. To provide a longer diffuser pool for bubble dissipation, the Plan C station that evolved was 8 feet farther downstream than that of Plan A. A diagonal wall was placed upstream from the counting house to create a positive attraction flow along the

wall. The trashrack vanes were placed 45 degrees to the flow for best overall flow conditions and structural simplicity. The top 13 to 15 inches of flow at the trashrack were blocked by a 2-foot-high solid plate on the vanes to provide a smooth surface for passage of floating debris along the rack. A low sill was placed across the center half of the pool at the downstream edge of the diffuser to prevent upstream flow from developing along the floor. Details of the plan are shown in photograph 12 and on plate 27.

29. Plates 28 and 29 show flow patterns and velocities that existed in the Plan C counting station with the Plan E regulating section with the minimum drop in head across the counting board and forebay elevations 257 and 268. The flow conditions existing with both forebay elevations are also shown in photograph 13. The counting station functioned well. With both extremes of operating conditions, attraction flow patterns and velocities were good. Floating debris passed readily along the trashrack. The surface turbulence indicated that most of the entrained air should be expelled in the longer diffuser pool and would not enter the counting station.

South Shore Regulating Section

Adapted Plan

30. The Plan E regulating section developed for the north shore ladder had to be modified for use in the south shore fish ladder since several aspects were different. The diffuser pool (pool 248) at the downstream end of the south shore regulating section was 16 feet long and had no counting station since it was located in pool 193 of the sloping ladder. The upstream end of the regulating section was 1.42 feet wider than that of the north shore ladder. The exit channel was narrower and had no baffles. The right half of the old regulating baffle section downstream

from baffle 265 was to be used as the walls of the new pools; therefore, pool 249 was to be 2.75 feet shorter than that developed for the north shore ladder and pools 29 and 30 were to be 1.92 feet longer than those developed for the north shore ladder. Details of the modifications at each end of the section to adapt Plan E to the south shore ladder are shown on plate 30. The model was modified to include all of the special features shown on plate 30 except the extra width of pools 28 through 35.

31. Baffle 249 was developed to have two 18- by 18-inch orifices on the floor and two higher orifices against the walls to function as submerged weirs (plate 30). The baffle at the downstream end of the exit channels had a 15-inch slot against the left wall to create an attraction path along the wall to slot 35. Flow conditions in the modified pools were satisfactory. Velocities and flow patterns in the pools with maximum and minimum forebay are shown in photograph 14 and on plates 31 and 32. With maximum forebay (elevation 268), velocities at slots 1 through 35 varied 5.3 to 6.7 fps and the velocity at slot 36 was 3.9 fps.

32. The tops of the existing baffles that were to be utilized in the modified regulating section were stiffening beams that overhung the baffles on the upstream side. The new baffles at slots 31, 33, and 35 were to have stiffening beams that overhung the downstream side of the downstream wall. With forebay elevation 267, only the beam in pool 30 was in the water. The water just touched the underside of the left two-thirds of the beam and rode up a maximum height of 0.3 foot on the right one-third. With forebay elevation 268, water was on the beams in pools 20, 22, 4, and 26 through 34 (photograph 15); however, the flow pattern was not disturbed by the shallow submergence of the beams. The beams did not appear to interfere with fish passage.

33. Fish passage in the prototype south shore ladder was to be evaluated after the modification. During those prototype observations, a temporary underwater counting station was to be installed at the upstream edge of slot 1. Flow around the proposed temporary station was observed in the model and revealed that the station would not disrupt the attraction path along the walls of pool 1 or create any disruptive flow pattern (photograph 16).

South Shore Counting Station

Original Weir 194

34. The existing south shore counting station, located in pool 193 of the sloping ladder section, was ineffective. Steelhead crossing the counting board fell back through it instead of entering the pool upstream, while shad entering the pool milled about and were reluctant to cross to weir 194. Apparently the high level of turbulence and the adverse flow direction in the upper three-quarters of the depth repelled the fish. The flow was highly entrained with air and the bubbles passing across the counting board made observation of the fish difficult. Studies to improve the flow pattern downstream from weir 194 and to create flow that would entrain less air were studied in the model. Details of the original weir 194, the pool downstream, and the counting station are shown in photograph 17 and on plate 33. The flow pattern in pool 194 and the adverse pattern in the upstream pool of the counting station are shown in photograph 17 and on plate 34.

Plan A Modification

35. In Plan A, weir 194 was modified to include deep notches in the weir at each wall and a shallow notch in the center of the weir with an orifice in the flow beneath the center notch. A baffle was installed on the wall downstream from the right notch to

deflect the flow toward the counting channel. Baffles were placed on the floor of pool 194 to disperse the outflow jets from the orifices of weir 195. The upper part of the vanes of the trashrack were covered with a solid plate which projected 1.5 feet into the water. Details of the modified weir (Plan A) are shown in photograph 18 and on plate 35. The modification created satisfactory velocities and flow patterns with both a 10- and 12-inch head on the weir (plates 36 and 37). Good attraction paths occurred through the full depth of the pool from the counting channel to both the right and center notches but only near the surface of the pool to the left notch. The absence of a deep attraction path to the left notch was considered acceptable since deep attraction paths existed to the other two notches. The baffles were needed to help create and stabilize the flow pattern. Although the deep notches created shooting flow that should entrain less air than the plunging flow of the original notches, the level of turbulence was high (photograph 18) and might have carried entrained air into the counting channel.

Plan A-1 Modification

36. In an attempt to create a larger pool upstream from the counting station to better dissipate the entrained air bubbles, weir 194 was removed (photograph 19) and a new weir was installed upstream to create the required head drop. Unacceptable attraction flow occurred in most of the enlarged pool (photograph 19 and plate 38). Flow conditions were improved by modifying weir 195 to be similar to the Plan A modification of weir 194 (plate 39). Good velocities and attraction paths occurred in the full depth through the center of the pool, near the right wall of the pool, and near the surface along the left wall of the pool (photograph 20 and plate 40). However, surface turbulence indicated that air would still be carried into the counting channel.

Plan B (Final Design) Modification

37. Plans A and A-1 both resulted in almost identical improvements in flow conditions; however, Plan A was selected for further study because it involved modifying only one weir. In Plan B (the final design which was constructed in the prototype) the lower part of the Plan A left notch was raised and widened. All of the vanes in the 2.5-foot section of the trashrack near the wall and the upper 1.5 feet of those in the adjacent 3.5-foot section of the trashrack were blocked with solid plates. The remaining portion of the trashrack was left open (photograph 21 and plate 41). Flow conditions with the Plan B modification were acceptable (photograph 21 and plates 42 and 43), and attraction flow along the trashrack was improved slightly over Plan A.

PART IV: PROTOTYPE OPERATION

38. Modifications developed in the model studies were incorporated in the prototype south and north shore fish ladders in the winters of 1970-71 and 1971-72, respectively. The south shore ladder regulating section was evaluated by the National Marine Fisheries Service during the summer of 1971 and performed satisfactorily.* Prototype operation, as evidenced in the model, indicates that flow from upstream of weir 194 is highly saturated with bubbles which remain in suspension and pass through the counting channel.

---

* Charles R. Weaver, Clark S. Thompson, and Frank J. Ossiander, "Evaluation of Fish Passage in the Vertical Slot Regulating Section of the South Shore Ladder at John Day Dam," National Marine Fisheries Service, June 1972.

V: SUMMARY

39. The flow regulating sections and fish-counting stations at both the north and south shore fish ladders at John Day Dam were modified to more effectively pass shallow-swimming fish such as shad and to improve fish counting and identification. A 1:10-scale model was used in modifying the Hell's Gate slot-orifice type regulating section into a slot-only design having a maximum head drop of approximately 6 inches per pool. The design was initially developed for the north shore ladder and adapted for the south shore ladder. The effectiveness of the design in passing fish was verified in full-scale tests at a fisheries laboratory and then later in the prototype. A vertical counting station was developed for the north shore ladder to replace a horizontal counting station. The station was developed for use with the then existing regulating section and with the modified section. The weir upstream from the south shore counting station was modified to create flow patterns that would attract fish to pass quickly from the counting station and continue on upstream.

TABLE A

HEADS ON BAFFLES

North Shore Regulating Section, Slot-Orifice Plan C

Slot and Orifice Flow

Baffle Number	Forebay Elevation in Feet-MSL								
	268	265	263	262	261	263	262	261	257
	Slot Sills of Baffles 263 to 267								
	In Place					Removed			
	Discharge in CFS								
	85.0	61.0	45.2	37.8	31.4	61.6	54.7	47.7	18.9
	Head on Baffle in Feet								
249	0.64	0.37	0.19	0.15	0.10	0.38	0.31	0.23	0.04
250	0.85	0.52	0.31	0.22	0.15	0.52	0.42	0.33	0.05
251	1.01	0.68	0.45	0.32	0.24	0.69	0.59	0.49	0.10
252	1.00	0.71	0.52	0.41	0.30	0.74	0.65	0.55	0.12
253	1.04	0.77	0.56	0.46	0.36	0.76	0.67	0.60	0.17
254	0.98	0.70	0.52	0.41	0.33	0.71	0.63	0.54	0.14
255	1.02	0.84	0.68	0.59	0.51	0.85	0.79	0.72	0.29
256	1.02	0.85	0.72	0.63	0.54	0.85	0.79	0.74	0.36
257	1.02	0.87	0.75	0.69	0.61	0.88	0.82	0.76	0.64
258	0.97	0.92	0.79	0.77	0.70	0.92	0.85	0.81	0.81
259	1.03	0.90	0.83	0.75	0.74	0.90	0.85	0.83	0.79
260	1.04	0.95	0.87	0.87	0.80	0.94	0.95	0.89	0.87
261	0.98	0.91	0.88	0.85	0.84	0.92	0.92	0.89	0.86
262	0.93	0.86	0.84	0.83	0.78	0.87	0.85	0.84	0.80
263	0.94	0.89	0.87	0.82	0.86	0.48	0.45	0.42	0.21
264	0.92	0.90	0.90	0.92	0.84	0.46	0.42	0.37	0.27
265	0.94	0.94	0.95	0.97	1.02	0.43	0.41	0.41	0.25
266	0.93	0.89	0.92	0.93	0.86	0.39	0.36	0.35	0.24
267	0.93	0.92	0.96	0.97	1.04	0.32	0.29	0.26	0.23
268	0.38	0.30	0.24	0.21	0.18	0.54	0.52	0.51	0.38
269	0.40	0.31	0.25	0.23	0.20	0.45	0.46	0.46	0.38

NOTES: 1. Details of regulating section shown on plate 4.
2. All orifices of baffle 249 open.

TABLE B

HEADS ON BAFFLES

North Shore Regulating Section, Slot-Orifice Plan C

Slot Flow Only

Baffle Number	Forebay Elevation in Feet-MSL								
	268	265	263	262	261	263	262	261	257
	Slot Sills of Baffles 263 to 267								
	In Place					Removed			
	Discharge in CFS								
	72.4	48.7	33.6	25.7	18.9	52.5	45.2	38.7	16.3
	Head on Baffle in Feet								
249	0.52	0.27	0.14	0.09	0.04	0.30	0.23	0.18	0.04
250	1.06	0.57	0.28	0.18	0.11	0.61	0.50	0.37	0.08
251	1.03	0.65	0.38	0.26	0.15	0.72	0.58	0.49	0.11
252	1.03	0.73	0.47	0.32	0.20	0.79	0.68	0.57	0.15
253	1.03	0.78	0.58	0.47	0.32	0.79	0.74	0.64	0.26
254	0.99	0.71	0.53	0.39	0.27	0.75	0.67	0.61	0.23
255	1.05	0.89	0.73	0.65	0.54	0.91	0.87	0.80	0.47
256	1.03	0.90	0.78	0.68	0.59	0.93	0.86	0.83	0.53
257	1.01	0.91	0.80	0.76	0.69	0.93	0.87	0.82	0.66
258	0.99	0.94	0.86	0.83	0.83	0.94	0.90	0.87	0.82
259	1.03	0.93	0.83	0.81	0.76	0.95	0.94	0.88	0.75
260	1.04	0.98	0.93	0.91	0.93	0.99	0.97	0.95	0.93
261	0.99	0.94	0.91	0.88	0.88	0.94	0.93	0.92	0.89
262	0.92	0.87	0.86	0.82	0.81	0.86	0.84	0.85	0.79
263	0.95	0.89	0.88	0.86	0.86	0.43	0.41	0.36	0.16
264	0.93	0.92	0.93	0.95	0.93	0.42	0.38	0.33	0.15
265	0.97	0.94	1.00	1.04	1.03	0.39	0.36	0.35	0.16
266	0.93	0.88	0.92	0.96	0.98	0.38	0.34	0.32	0.14
267	0.94	0.92	0.94	0.95	0.95	0.30	0.29	0.26	0.16
268	0.27	0.17	0.11	0.09	0.05	0.44	0.33	0.29	0.24
269	0.29	0.21	0.14	0.10	0.08	0.23	0.31	0.31	0.28

NOTES: 1. Details of regulating section shown on plate 4.
2. Side orifices of baffle 249 open; center orifice closed.

TABLE C

SLOT VELOCITIES

North Shore Regulating Section, Slot Plan E

Slot Number	Forebay Elevation in Feet - MSL								
	268	265	263	262	261	263	262	261	257
	Sills in Slots 24 to 35								
	In Place					Removed			
	Discharge in CFS								
	70.2	46.8	33.4	27.2	21.4	58.5	51.2	44.6	20.0
	Velocity in FPS								
249 Right	6.6	5.5	4.3	3.4	2.8	6.3	5.9	5.3	2.5
Center	5.1	4.0	2.9	2.6	2.2	4.5	4.6	4.0	2.2
Left	5.9	4.5	3.6	2.9	2.3	5.1	4.8	4.3	2.2
1	5.8	4.6	3.3	2.9	2.2	5.3	4.8	4.2	2.1
2	6.3	4.8	3.6	3.1	2.5	5.5	5.1	4.7	2.3
3	6.3	4.8	3.7	3.2	2.6	5.5	5.3	4.7	2.5
4	6.4	5.0	4.2	3.4	2.9	5.8	5.5	5.1	2.6
5	6.4	5.3	4.2	3.6	3.1	5.9	5.8	5.0	2.9
6	6.6	5.4	4.6	3.9	3.3	5.8	5.8	5.6	2.8
7	6.4	5.4	4.7	4.2	3.6	6.1	5.8	5.3	3.3
8	6.3	5.4	4.6	4.0	3.3	5.9	5.9	5.4	3.3
9	6.7	5.6	5.3	4.6	4.0	6.4	6.1	5.6	3.9
10	6.7	5.4	5.3	4.6	4.0	6.2	6.2	5.8	3.7
11	6.9	5.9	5.5	5.0	4.6	6.4	6.2	5.8	4.3
12	6.6	6.1	5.4	5.0	4.5	6.3	6.2	5.9	4.2
13	6.7	6.1	5.6	5.3	4.8	6.6	6.4	5.9	4.6
14	6.7	6.1	5.5	5.1	4.6	6.2	6.3	5.9	4.6
15	6.7	6.2	5.6	5.4	5.0	6.3	6.4	5.9	5.0
16	6.7	6.2	5.6	5.4	5.0	6.4	6.2	5.9	5.1
17	6.4	6.1	5.8	5.4	5.0	6.2	6.3	5.8	5.1
18	6.4	5.9	5.9	5.6	5.3	6.3	6.1	5.6	5.0
19	6.6	5.8	5.9	5.6	5.5	6.4	6.1	5.9	5.4
20	6.4	6.1	5.9	5.5	5.4	6.6	6.4	5.9	5.1

11	6.9	5.9	5.5	5.0	4.6	6.4	6.2	5.8	4.3
12	6.6	6.1	5.4	5.0	4.5	6.3	6.2	5.9	4.2
13	6.7	6.1	5.6	5.3	4.8	6.6	6.4	5.9	4.6
14	6.7	6.1	5.5	5.1	4.6	6.2	6.3	5.9	4.6
15	6.7	6.2	5.6	5.4	5.0	6.3	6.4	5.9	5.0
16	6.7	6.2	5.6	5.4	5.0	6.4	6.2	5.9	5.1
17	6.4	6.1	5.8	5.4	5.0	6.2	6.3	5.8	5.1
18	6.4	5.9	5.9	5.6	5.3	6.3	6.1	5.6	5.0
19	6.6	5.8	5.9	5.6	5.5	6.4	6.1	5.9	5.4
20	6.4	6.1	5.9	5.5	5.4	6.6	6.4	5.9	5.1
21	6.7	5.9	5.9	5.6	5.8	6.3	6.1	5.9	5.6
22	6.3	6.1	6.1	5.5	5.5	6.1	6.4	5.9	4.8
23	6.6	5.9	5.8	5.5	5.5	6.1	6.3	5.8	5.6
24	6.2	6.1	5.9	5.4	5.4	5.4	5.4	5.0	3.3
25	6.4	6.2	5.6	5.6	5.6	5.4	5.0	5.0	4.0
26	5.9	5.1	5.9	5.5	5.6	5.3	5.0	5.0	3.9
27	6.2	5.9	5.9	5.8	5.5	5.4	5.1	4.8	4.3
28	6.4	5.6	5.9	5.8	5.6	5.8	5.4	5.3	4.3
29	6.2	5.6	5.5	5.5	5.3	5.3	5.1	4.7	4.5
30	5.9	5.9	5.9	5.4	6.2	5.1	5.0	4.8	3.9
31	6.4	5.9	5.6	5.5	5.3	5.1	4.8	5.0	4.0
32	5.9	5.4	5.3	5.5	5.8	4.7	4.6	4.6	3.6
33	6.2	5.8	5.4	5.5	5.5	5.0	5.0	4.7	3.9
34	6.1	5.1	5.4	5.4	5.5	5.1	4.6	4.7	3.9
35	6.2	5.1	5.4	5.3	5.0	4.8	4.6	4.6	4.0
268	4.6	3.6	3.2	2.8	2.5	5.3	4.8	5.2	5.3
269	4.0	2.9	2.6	2.6	2.2	4.6	3.6	4.5	4.7

NOTES: 1. Velocity measured in the slot 1 ft below the downstream water surface.
2. Details of the regulating section shown on plate 12.

TABLE C

TABLE D

MINIMUM DEPTHS

North Shore Regulating Section, Slot Plan E

Slot No.	Forebay Elevation in Feet-MSL					
	262		261		257	
	Removable Sills					
	In		In		Out	
	Tailwater Depth at Slot in Feet					
	Floor	Sill	Floor	Sill	Floor	Sill
1	5.6		5.5		5.5	
10	4.3		4.0		3.9	
11	4.2		3.9		3.8	
12	4.3		3.8		3.7	
13	4.2		3.7		3.6	
14	4.3		3.8		3.6	
15	4.3		3.7		3.6	
16	4.4		3.8		3.6	
17	4.4		3.7		3.6	
18	4.4		3.8		3.6	
19	4.5	4.2	3.7	3.4	3.6	3.3
20	4.8	4.3	4.0	3.5	3.8	3.3
21	5.0	4.2	4.2	3.4	4.0	3.2
22	5.3	4.3	4.5	3.5	4.3	3.3
23	5.5	4.3	4.7	3.5	4.5	3.3
31	8.8	4.9	7.9	4.0	4.9	
32	9.3	4.6	8.5	3.8	5.2	
33	9.7	4.6	8.8	3.7	5.1	
34	10.3	4.8	9.4	3.9	5.4	
35	10.9	5.4	10.0	4.5	5.4	

NOTES: Details of regulating section shown on plate 12.

TABLE E

SELF-CLEANING CHARACTERISTICS

North Shore Counting Station Trash Rack

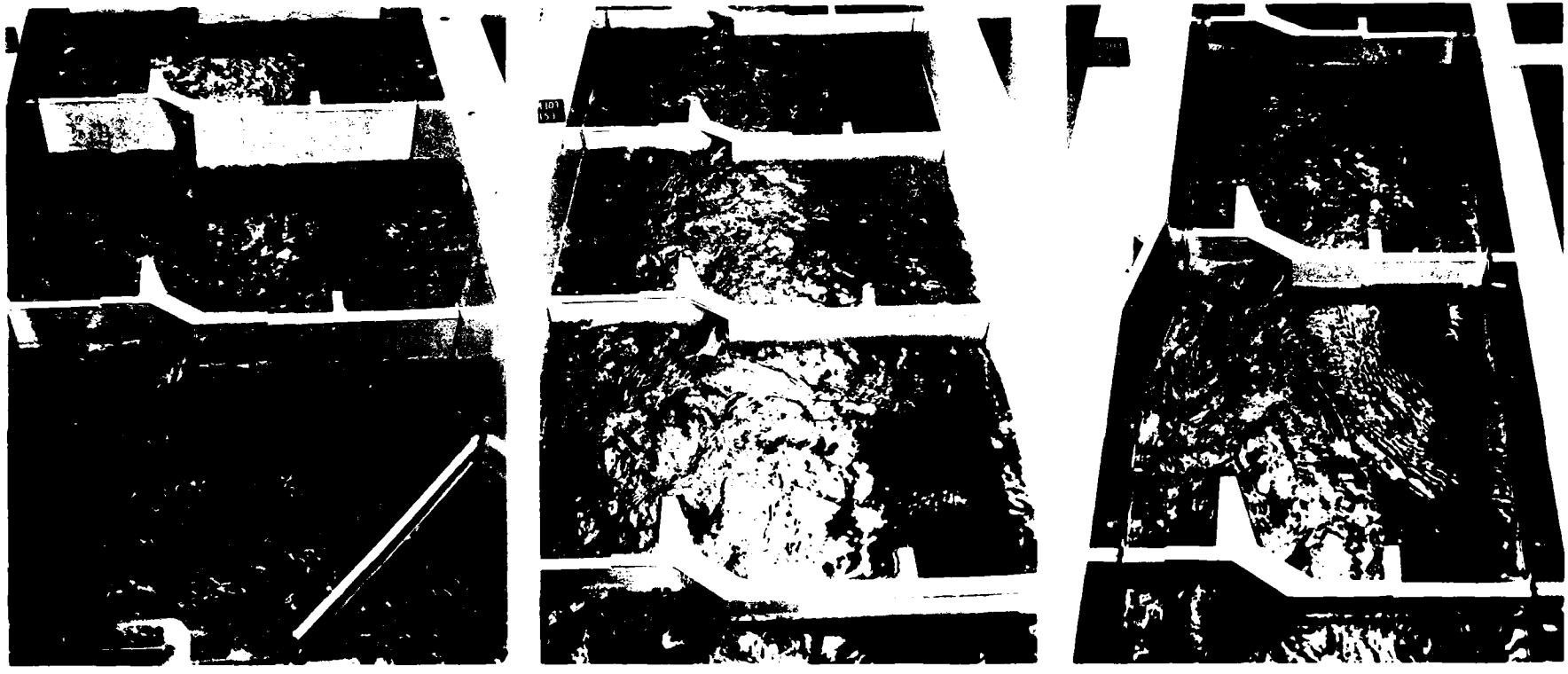
Vane Alignment to Flow	Discharges - CFS		Head Drop across Counting Board	Self-cleaning Time - Minutes
	Regulating Section	Diffuser		
Parallel	86	0	Minimum	Trash retained over 16 minutes
45 degrees				11.0
90 degrees				4.2
Parallel	86	0	3 in.	1.9
45 degrees				1.7
90 degrees				1.5
Parallel	45	37	Minimum	Trash retained
45 degrees				70 percent of trash retained over 30 minutes
90 degrees				70 percent of trash retained over 30 minutes
Parallel	45	37	3 in.	8.2
45 degrees				5.9
90 degrees				7.3

NOTES: 1. Time was average time of 3 to 5 tests in which approximately 20 pieces of trash 5/8- by 2 1/2- by 15 in. were spread across the trash rack at the water surface at the beginning of each test.
2. Location of the trash rack is shown on plate 17.

Looking upstream

Looking downstream

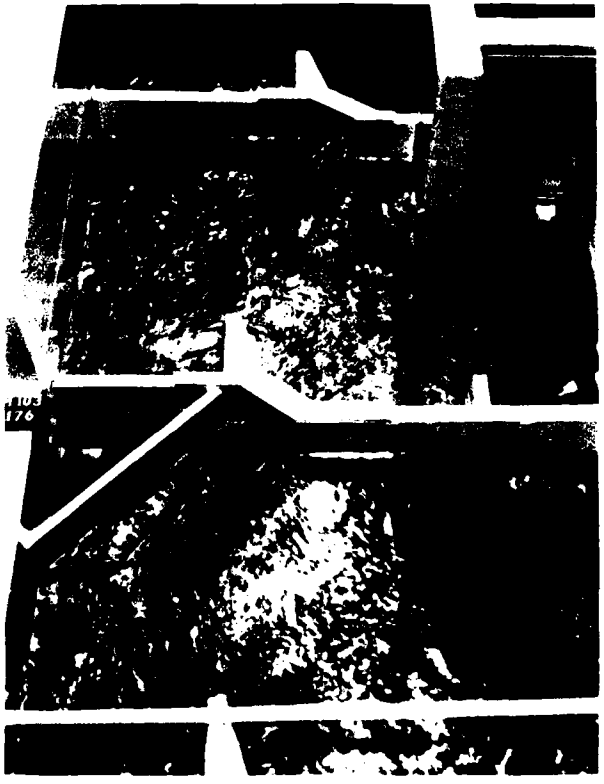
Photograph 1. Plan A regulating section. Typical slot-orifice baffles and entrance of bypass channel blocked with screen for flow with high forebay level.



Diffuser pool and pool 149 | Pools 255 to 257 | Pools 263 and 264

Photograph 2. Flow in plan A regulating section with forebay elevation 268.

Pools 249 and 250,
forebay elevation 262



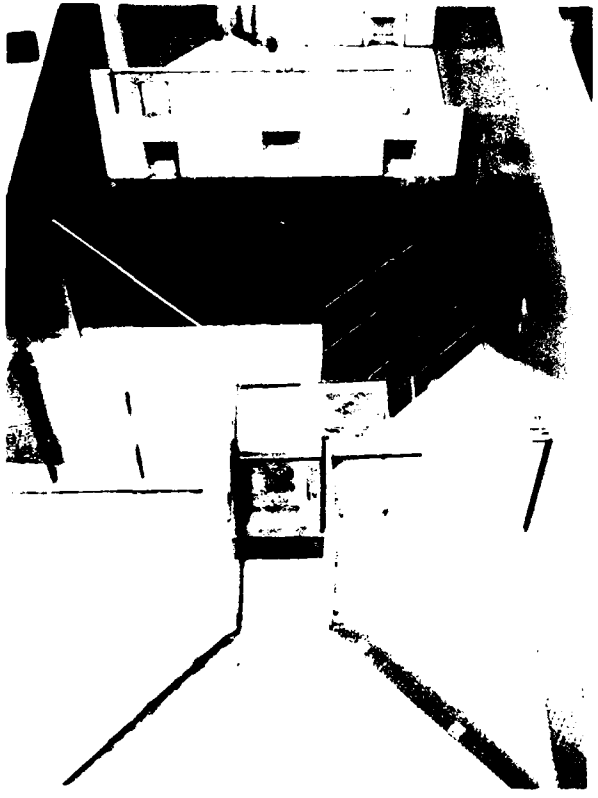
Pools 259 and 260,
forebay elevation 268

Photograph 3. Flow in plan B regulating section.
(Page 1 of 2)

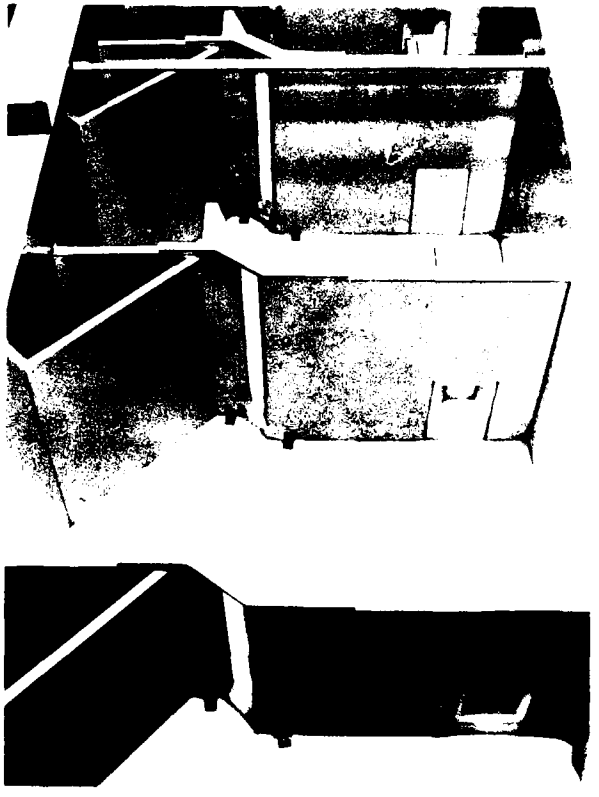
Pools 262 and 263,
forebay elevation 268

Pools 267 and exit channel,
forebay elevation 268

Photograph 3. Flow in plan B regulating section.
(Page 2 of 2)



Counting station, baffle 249

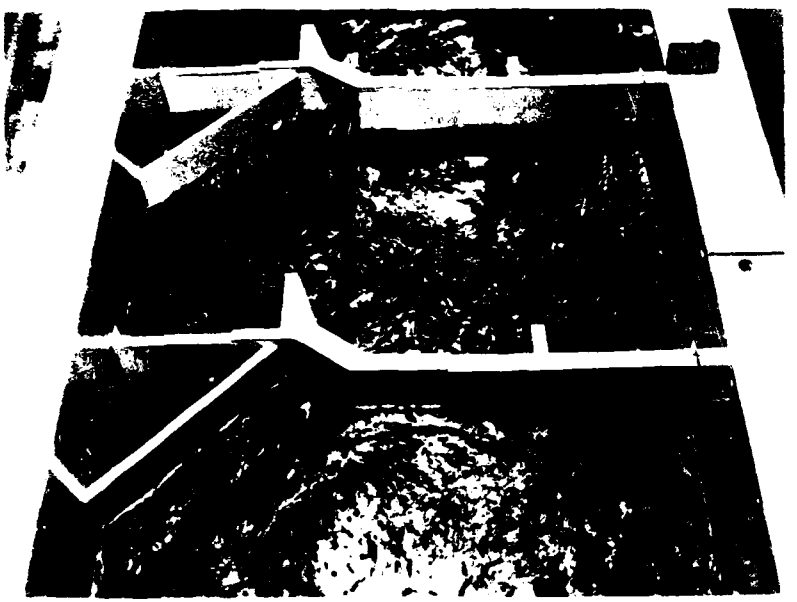


Typical slot-orifice baffles

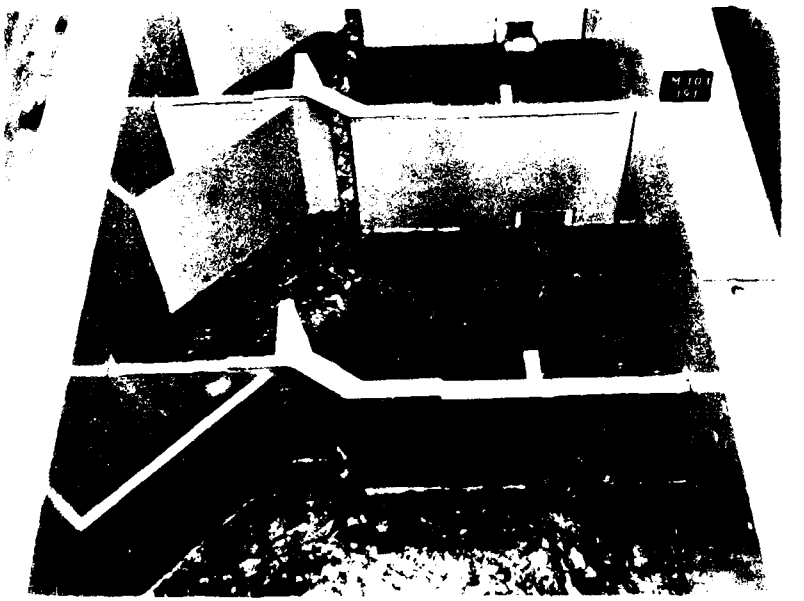
Photograph 4. Plan C regulating section, dry bed
(Page 1 of 2)

Exit channel

Photograph 4. Plan C regulating section, dry bed
(Page 2 of 2)

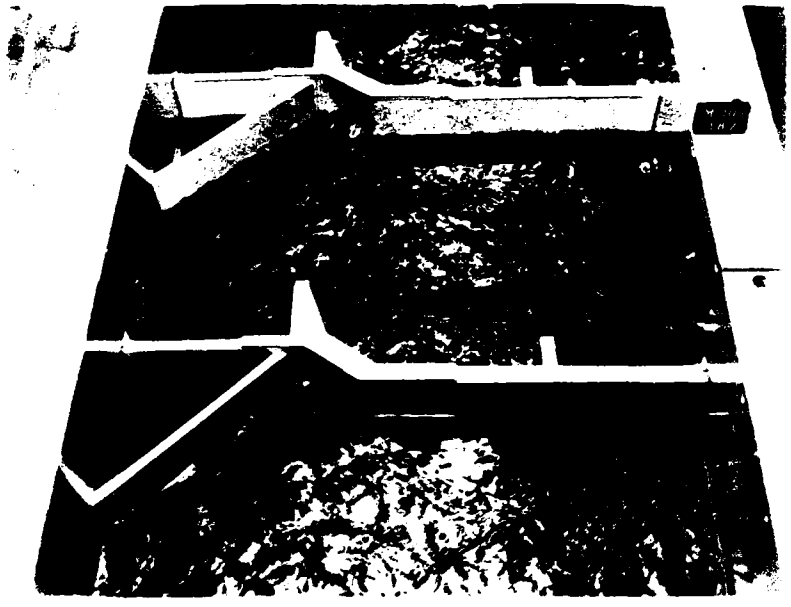


Forebay elevation 268



Forebay elevation 257

Photograph 5. Flow in plan C regulating section pool 255.

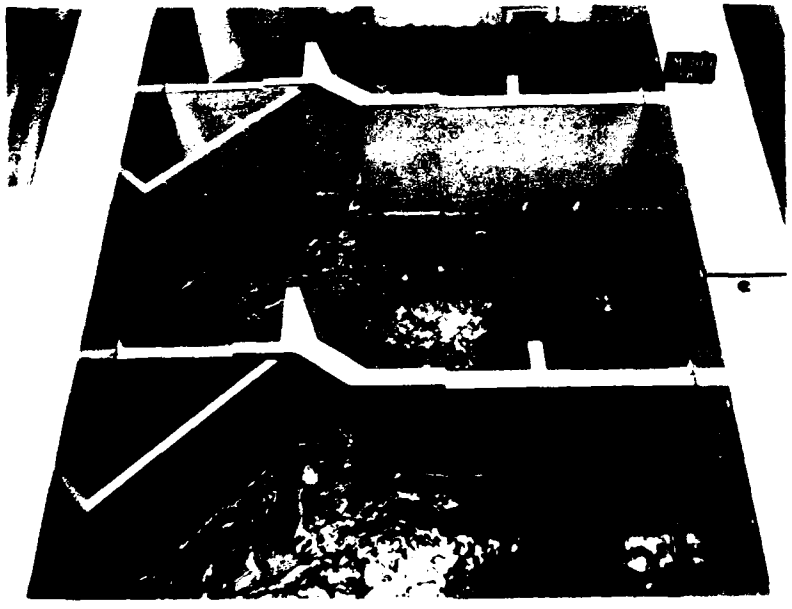


Typical pool 255

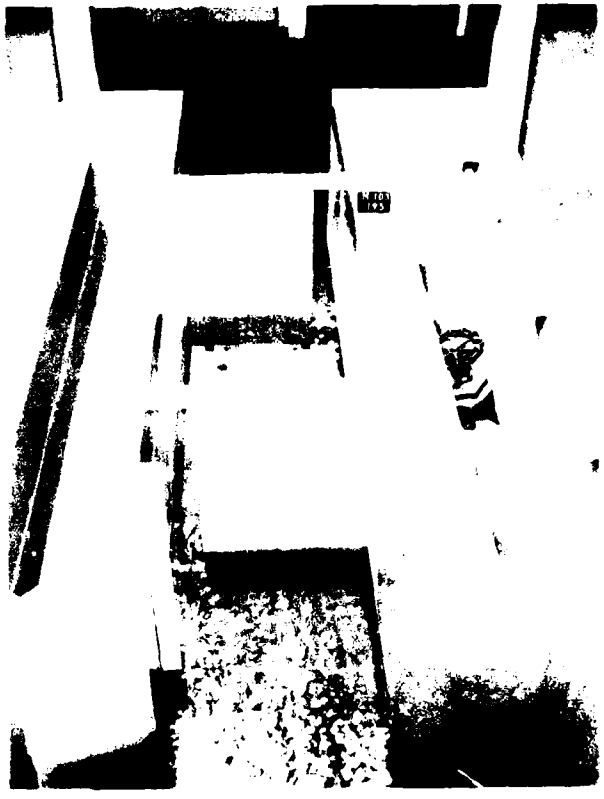
Exit channel

Forebay elevation 268

Photograph 6. Flow in plan C regulating section, slot flow only.
(Page 1 of 3)



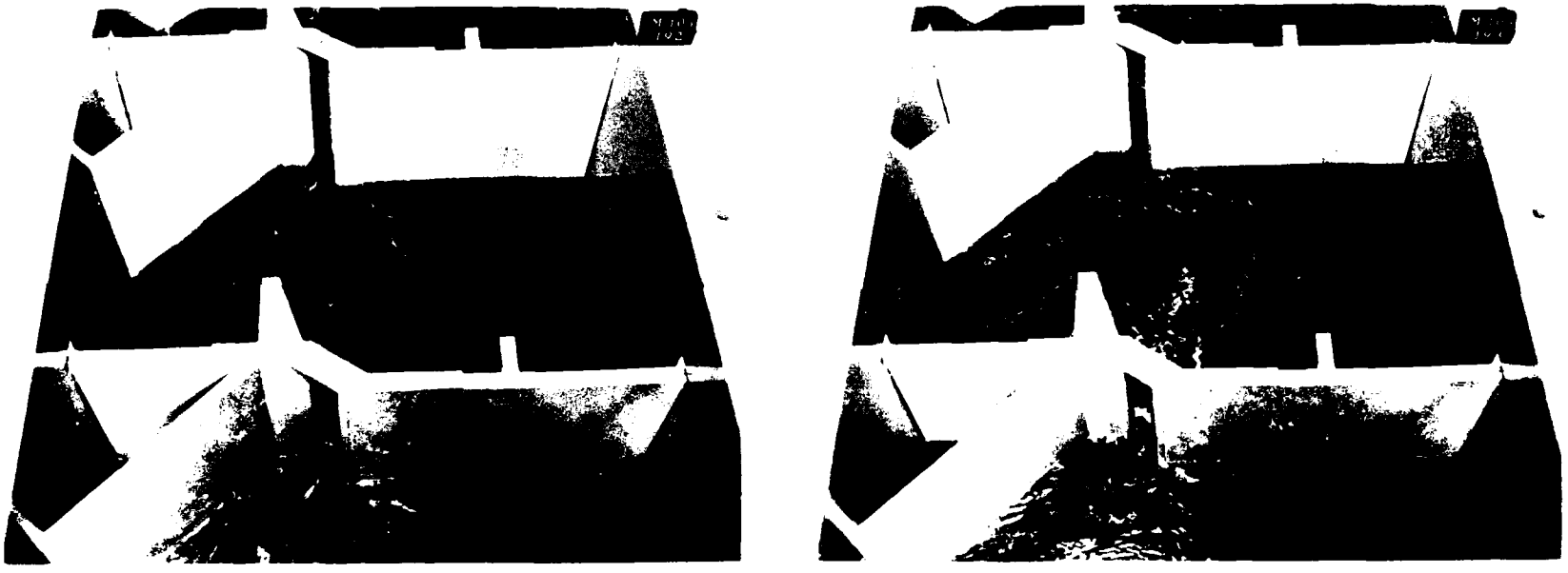
Typical pool 255



Exit channel

Forebay elevation 257

Photograph 6. Flow in plan C regulating section, slot flow only.
(Page 2 of 3)

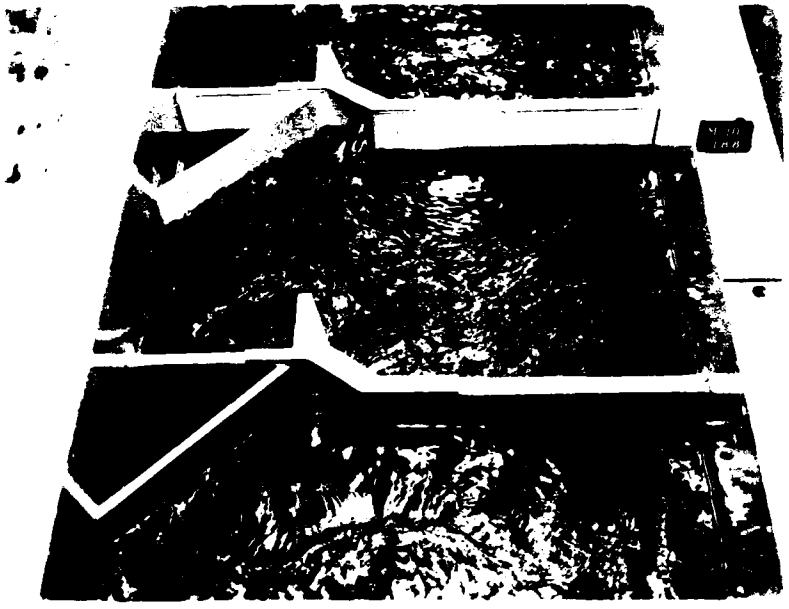


With sills in slots

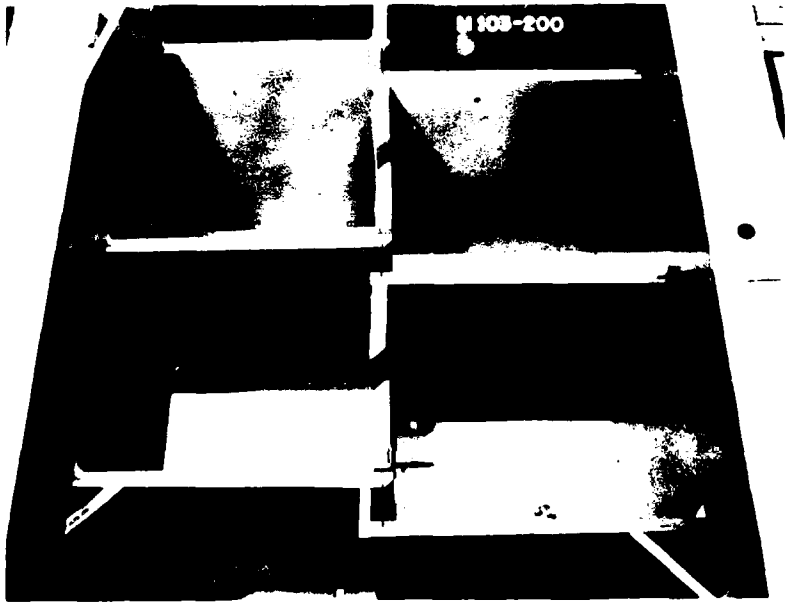
Without sills in slots

Pool 265, forebay elevation 262

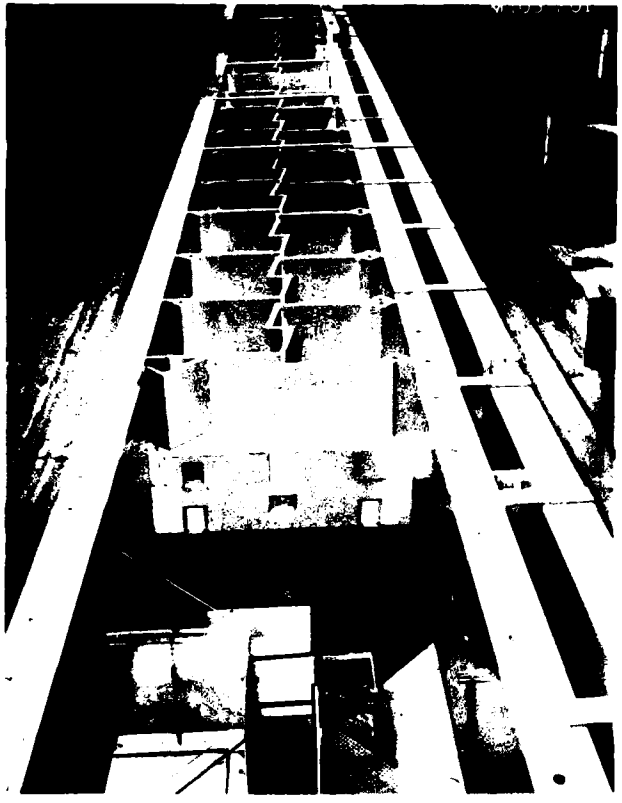
Photograph 6. Flow in plan C regulating section, slot flow only.
(Page 3 of 3)



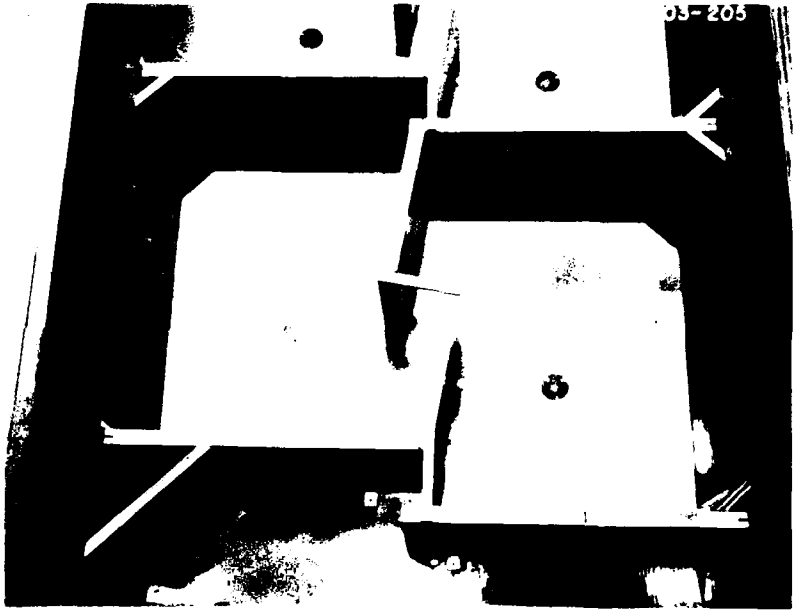
Photograph 7. Flow in plan C regulating section, slot flow only, fins removed.



Photograph 8. Plan D regulating section.

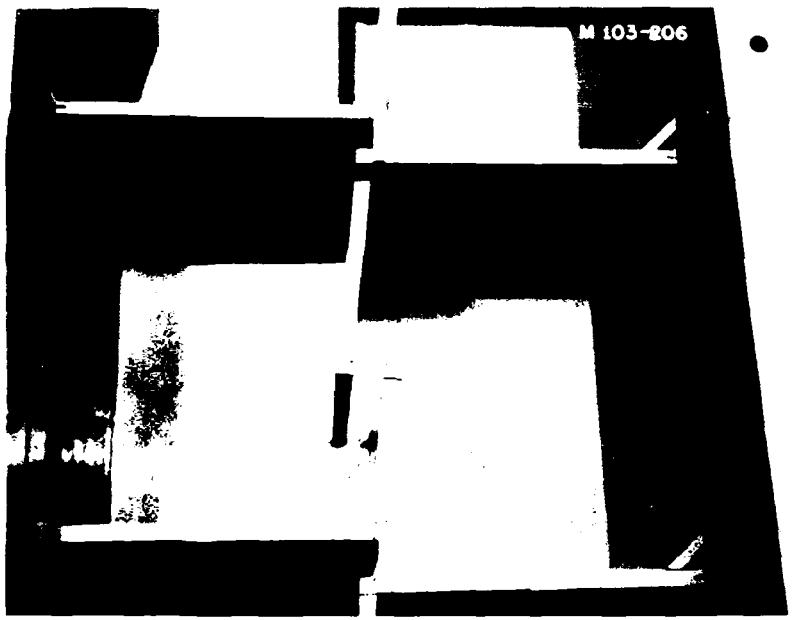


Looking upstream

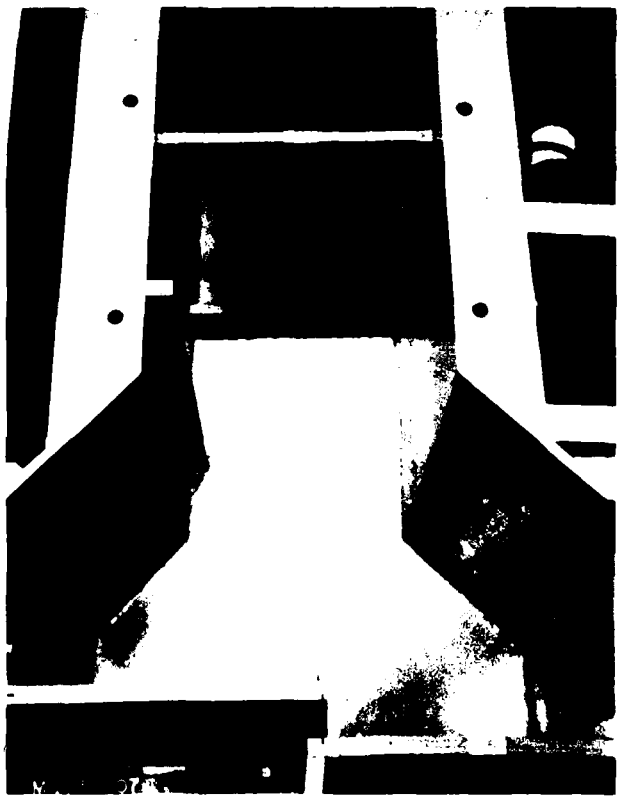


Pools 1 and 2

Photograph 9. Plan E regulating section.
(Page 1 of 2)

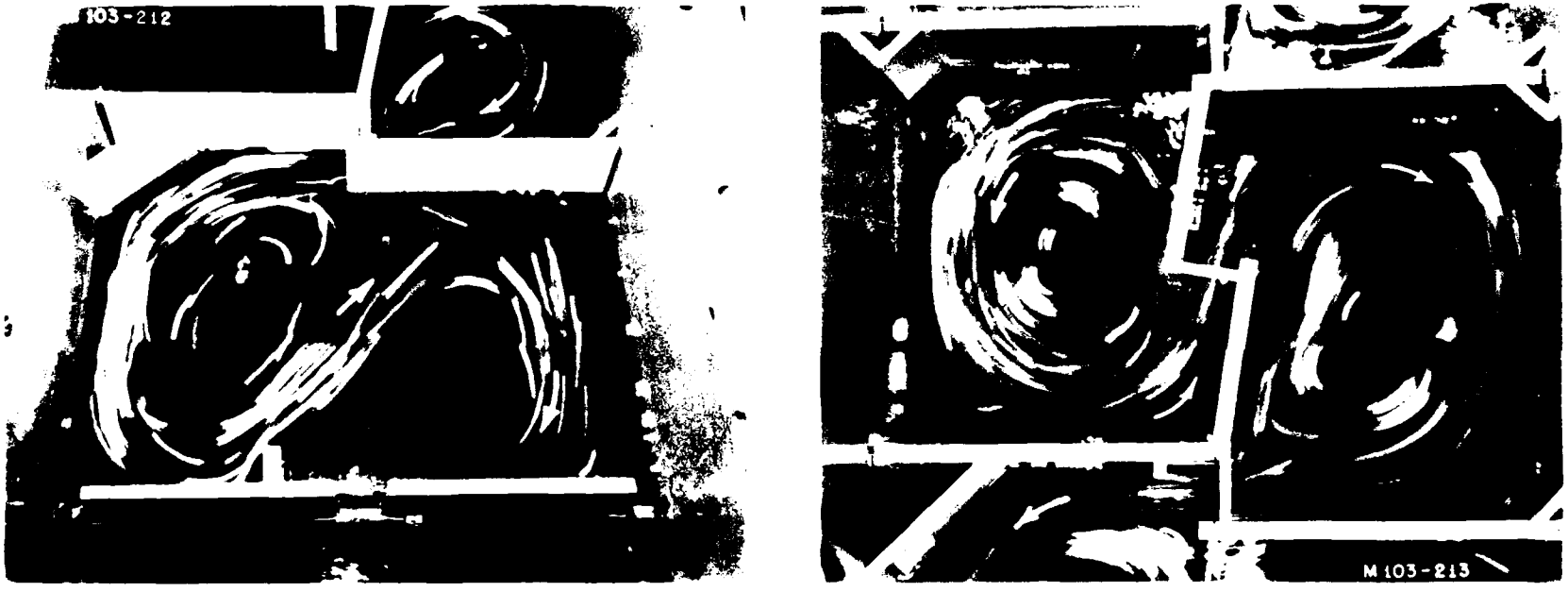


Pools 25 and 26



Pool 35 and exit baffle 268

Photograph 9. Plan E regulating section
(Page 2 of 2)

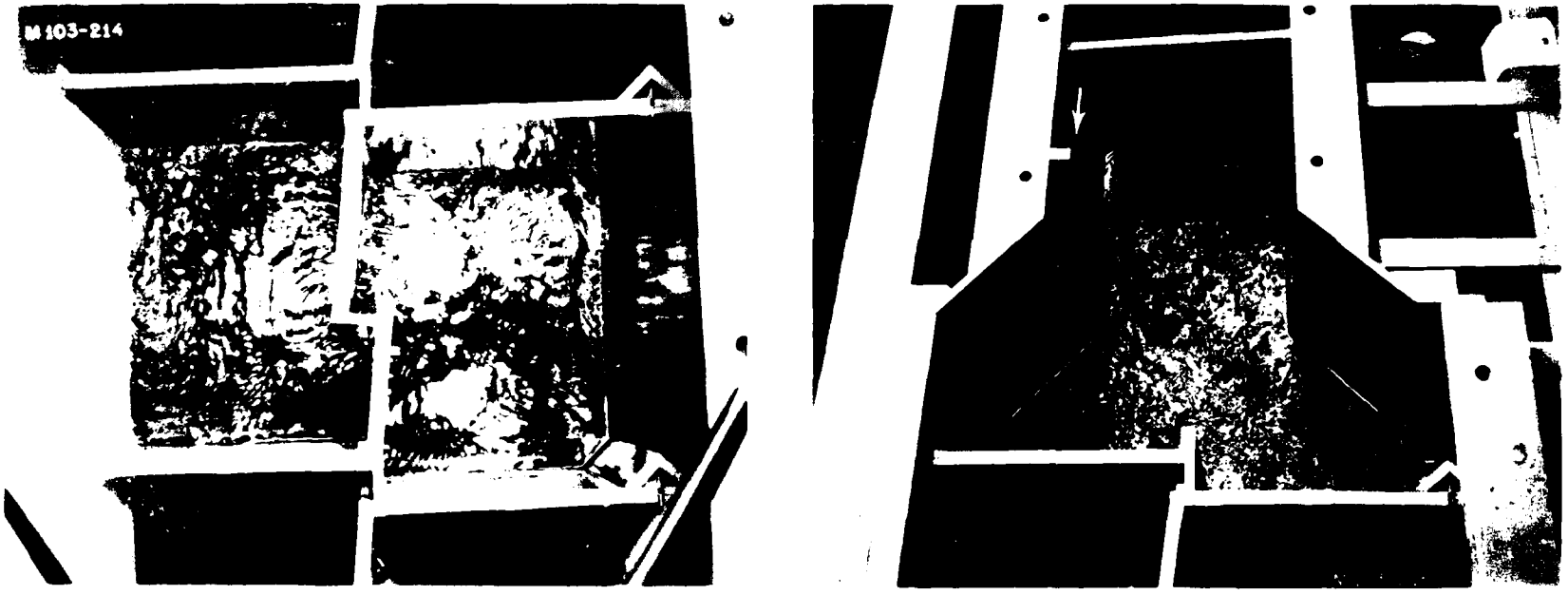


Pool 249

Pools 1 and 2

Forebay pool 257

Photograph 10. Flow in plan E regulating section.
(Page 1 of 5)

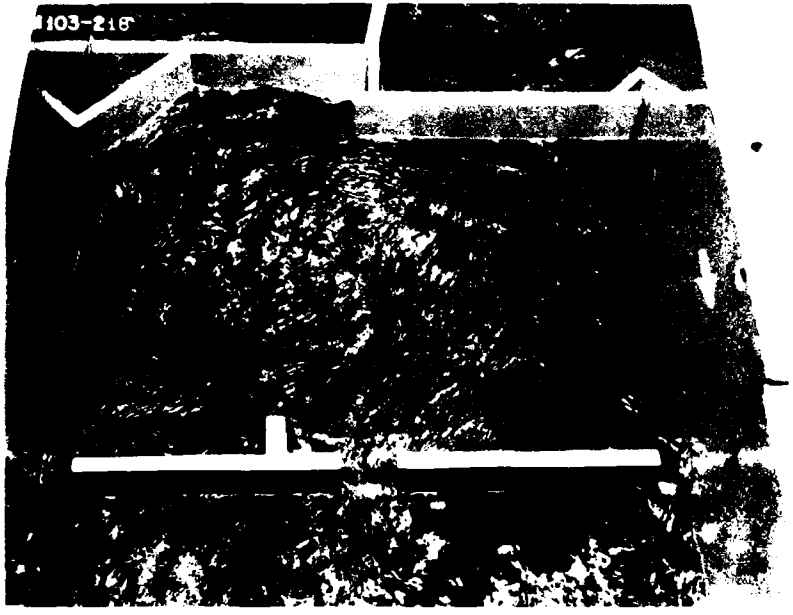


Pools 25 and 26

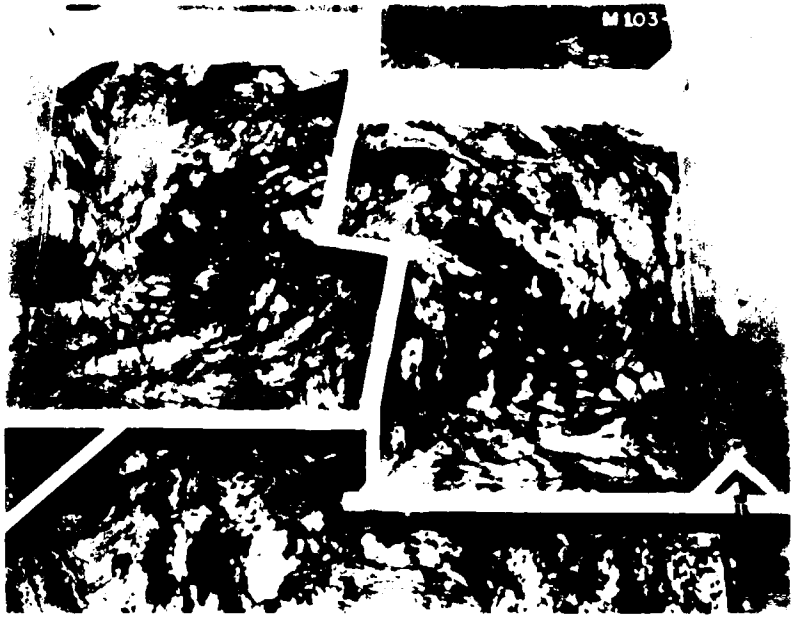
Pool 35

Forebay pool 257

Photograph 10. Flow in plan E regulating section.
(Page 2 of 5)



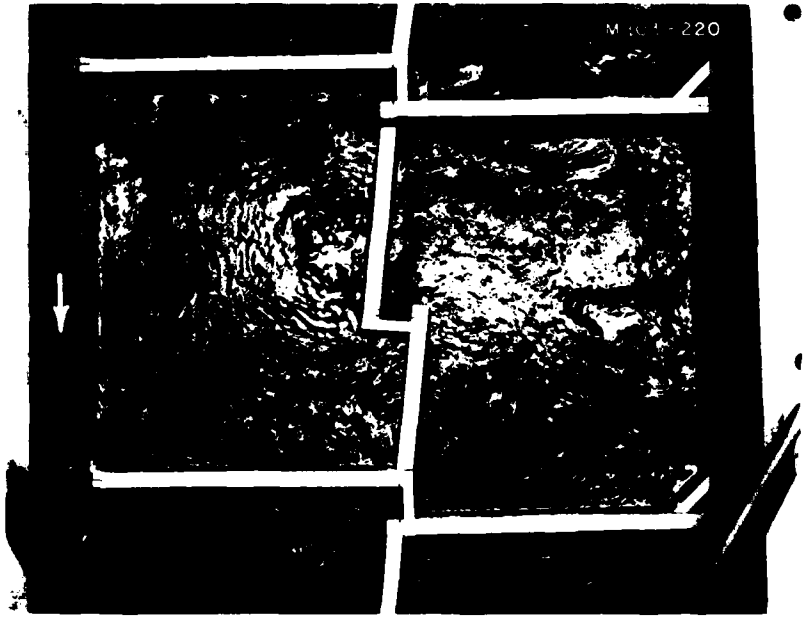
Pool 249



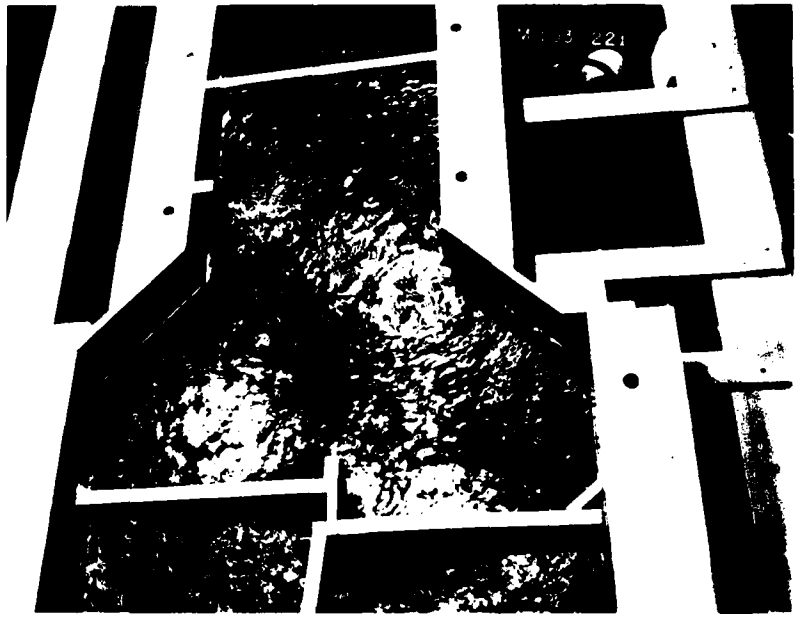
Pools 1 and 2

Forebay pool 268

Photograph 10. Flow in plan E regulating section.
(Page 3 of 5)



Pools 25 and 26



Pool 35

Forebay pool 268

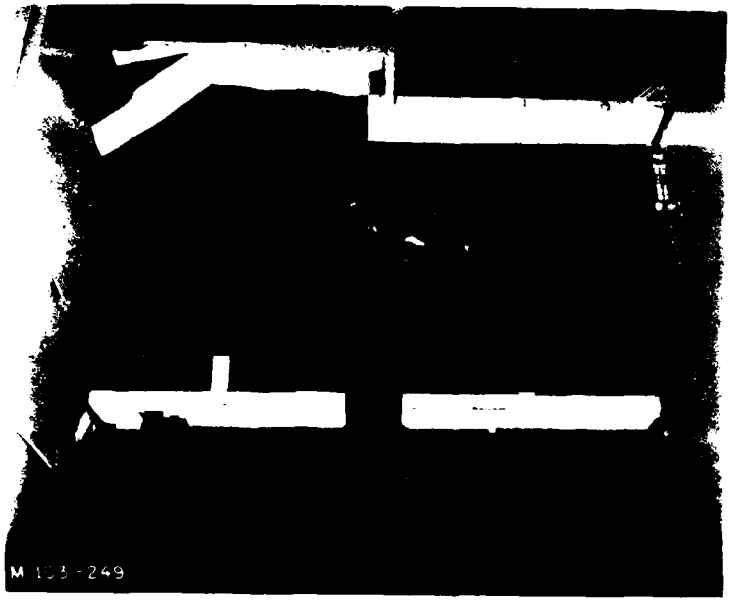
Photograph 10. Flow in plan E regulating section.
(Page 4 of 5)

Pool 1, looking upstream

Pool 2, looking upstream

Full-scale test pools, forebay elevation 268, Fisheries Engineering Research Laboratory

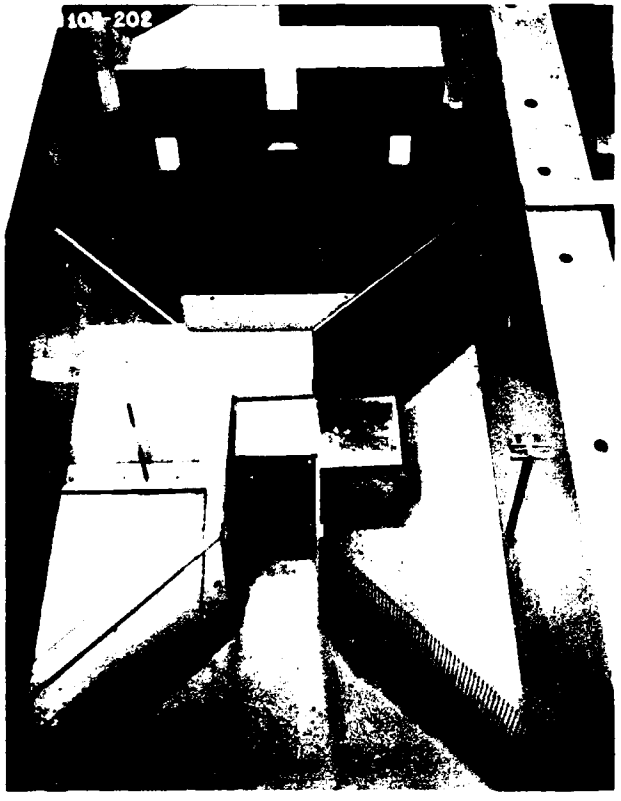
Photograph 10. Flow in plan E regulating section.
(Page 5 of 5)



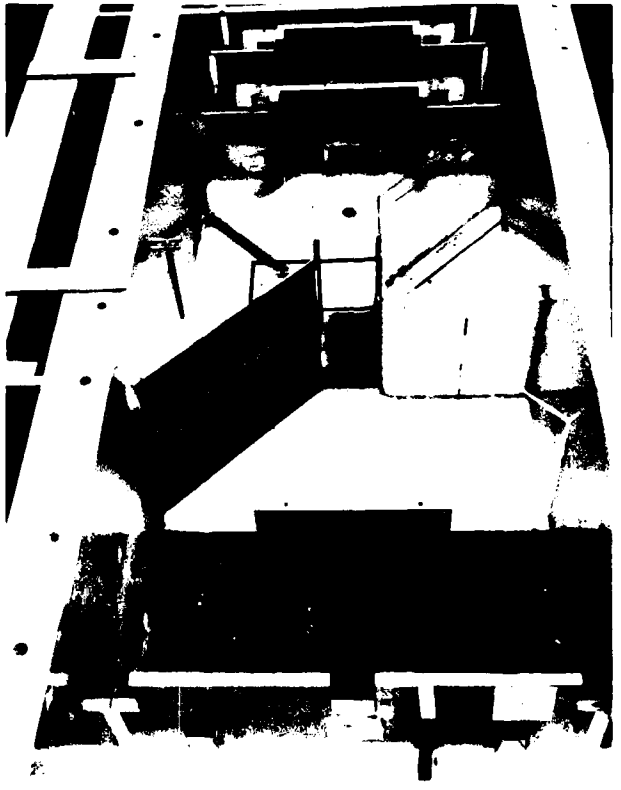
With proposed new fin on baffle 249

With existing fins on baffle 249

Photograph 11. Flow in pool 249 of plan E regulating section with forebay elevation 268.



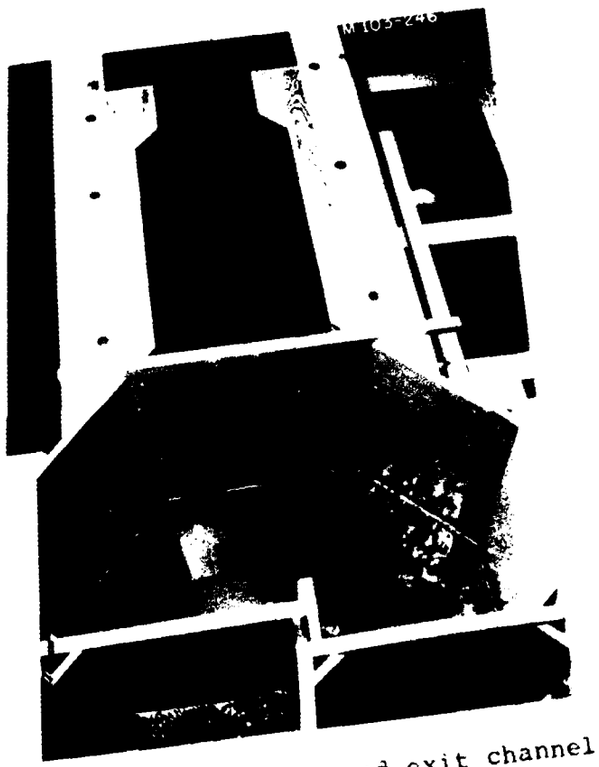
Looking upstream



Looking downstream

Photograph 12. Plan C north shore counting station.
(Page 1 of 2)

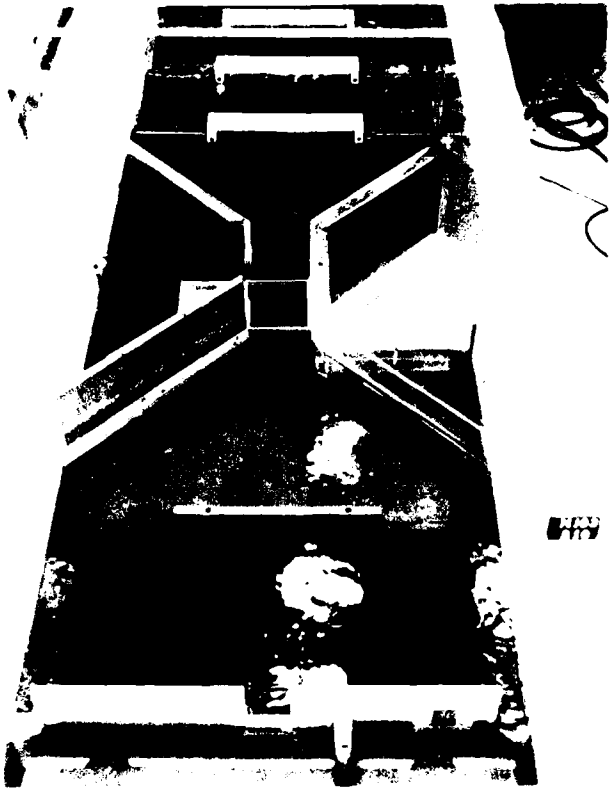
Pools 248 and 249



Pool 35 and exit channel

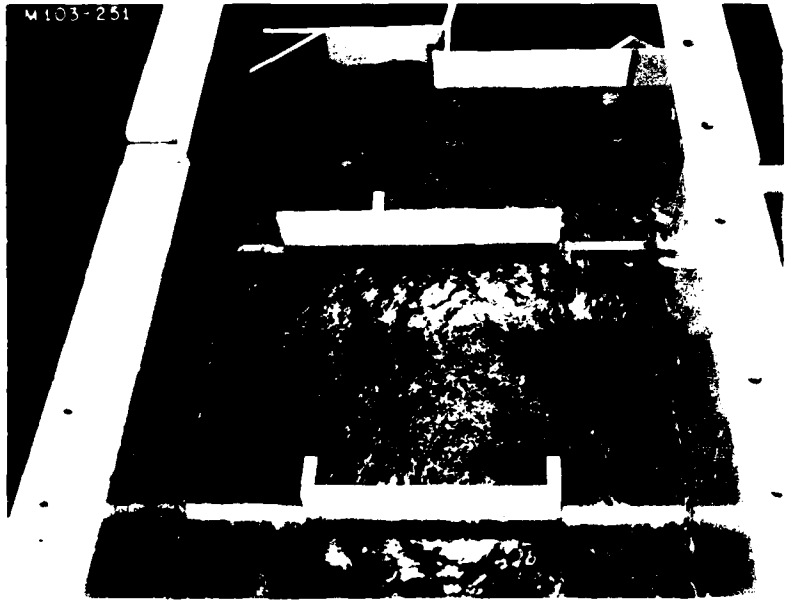
Photograph 12. Plan C north shore counting station.
(Page 2 of 2)

Forebay elevation 268



Forebay elevation 257

Photograph 13. Flow through plan C north shore counting station.

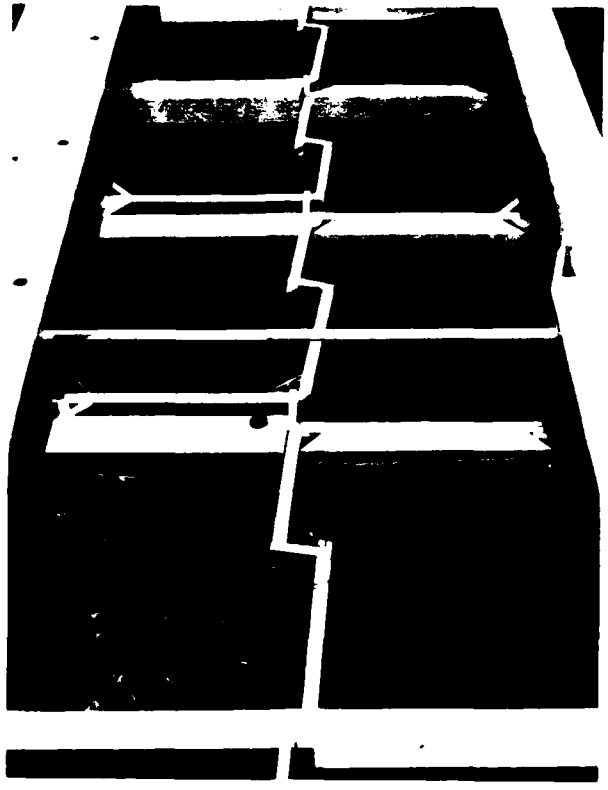


Pools 248 and 249

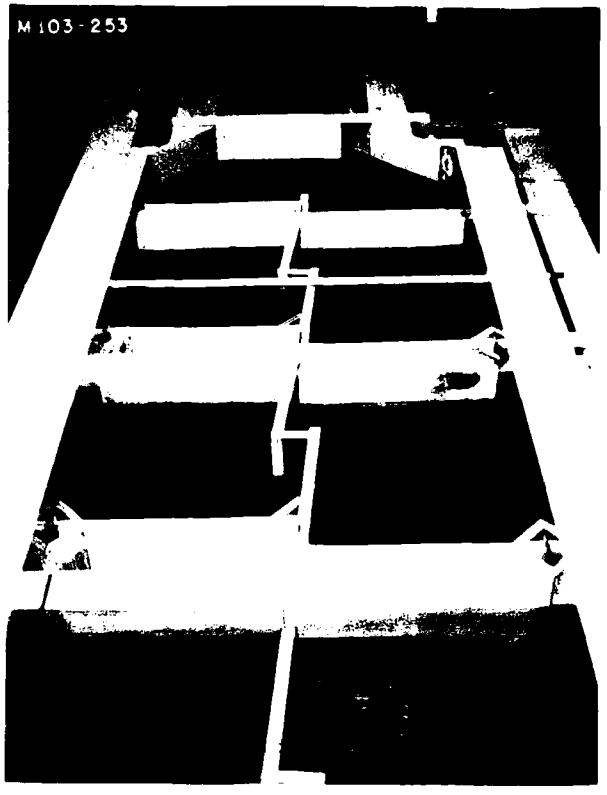
Pool 35 and exit channel

Forebay elevation 268

Photograph 14. Flow in south shore plan E regulating section.

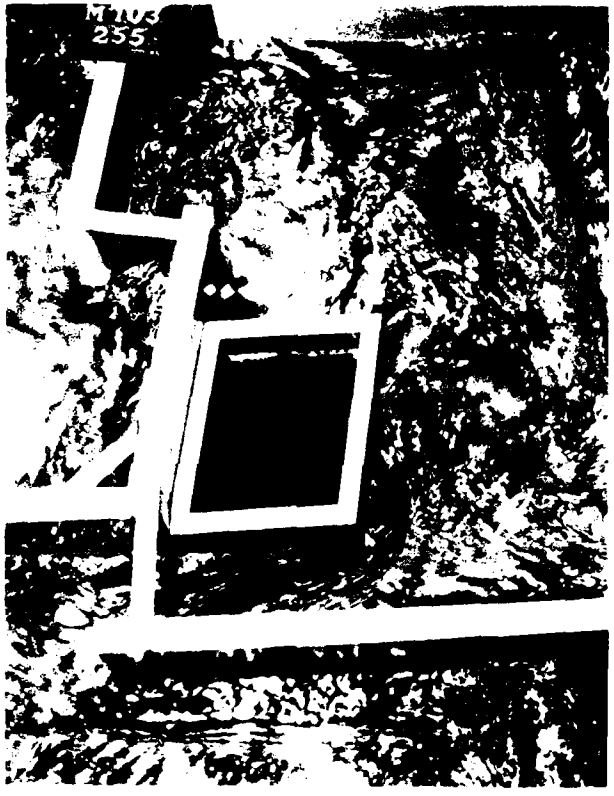


Pools 23 to 30, looking downstream

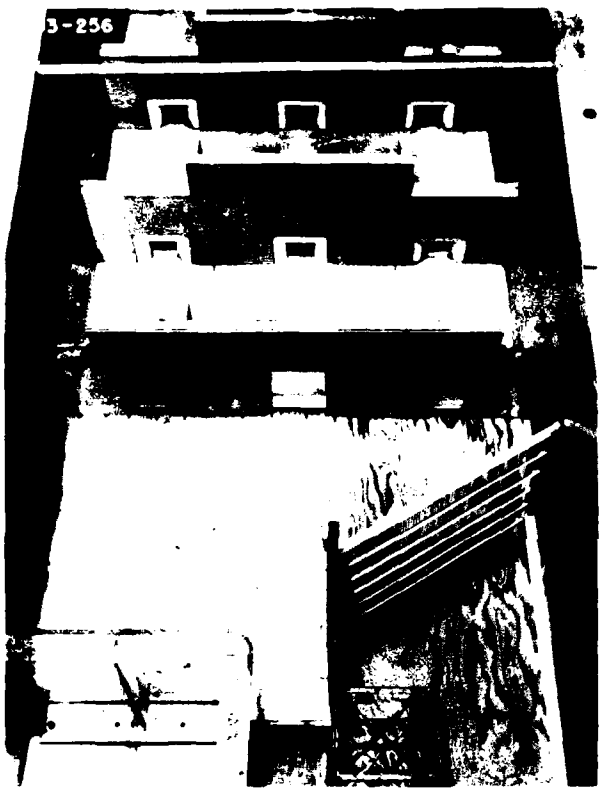


Pools 29 to 34, looking upstream

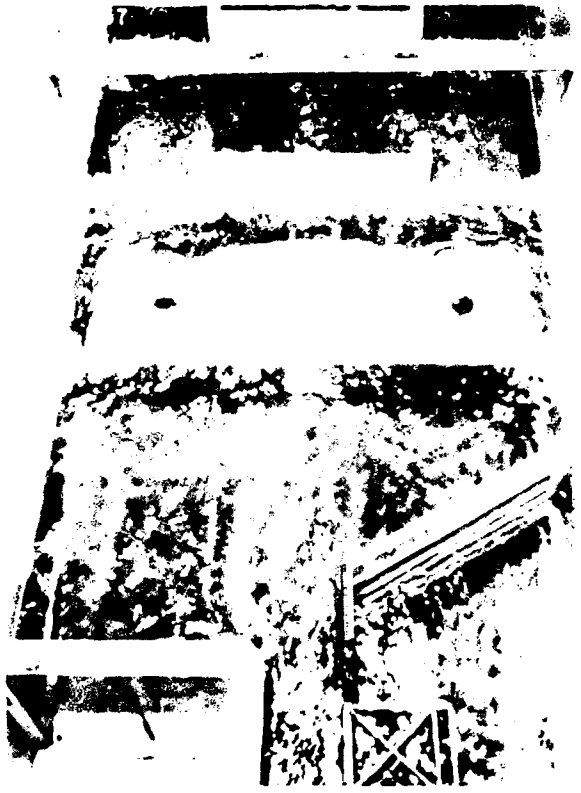
Photograph 15. Flow on stiffening beams of south shore plan E regulating section with forebay elevation 268.



Photograph 16. Flow around temporary counting station at slot 1 in south shore plan E regulating section with forebay elevation 268.



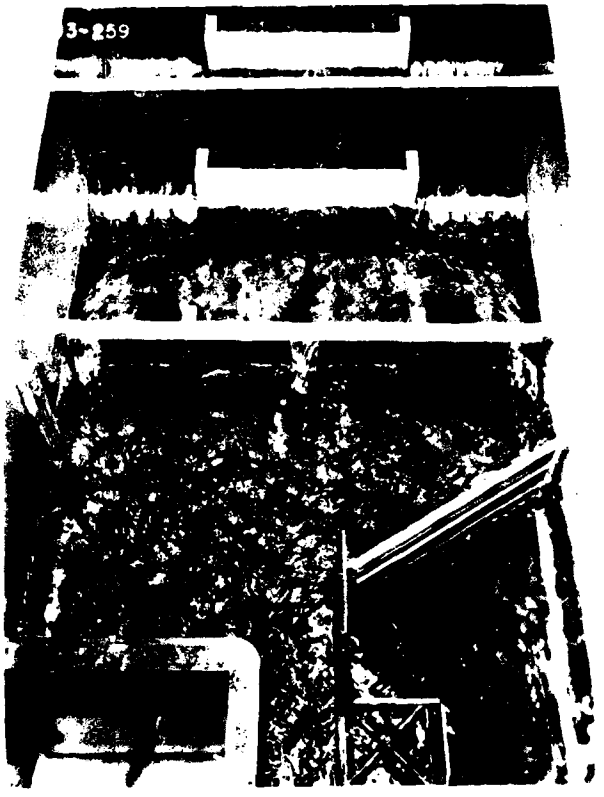
Looking upstream



Flow with 12-inch head on weirs

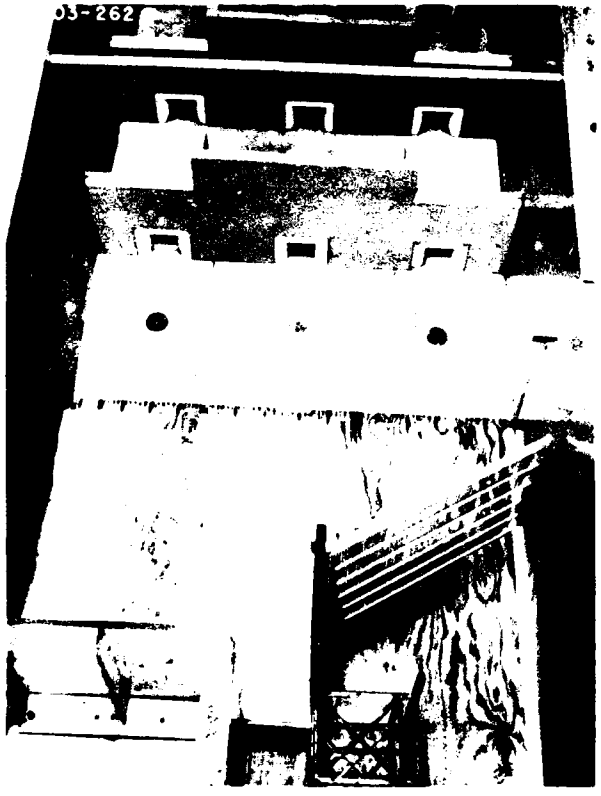
Photograph 17. South shore counting station with original weir 194.

Looking upstream

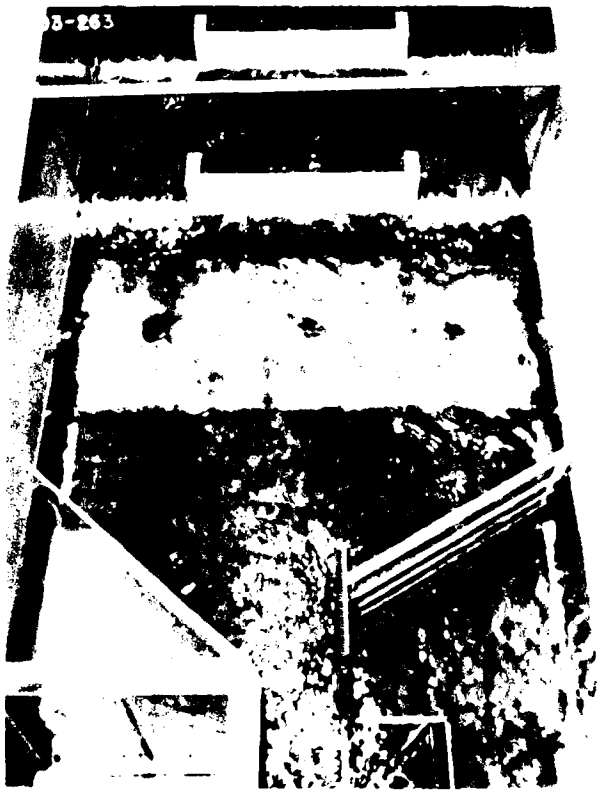


Flow with 12-inch head on weirs

Photograph 18. South shore counting station with plan A modified weir 194.

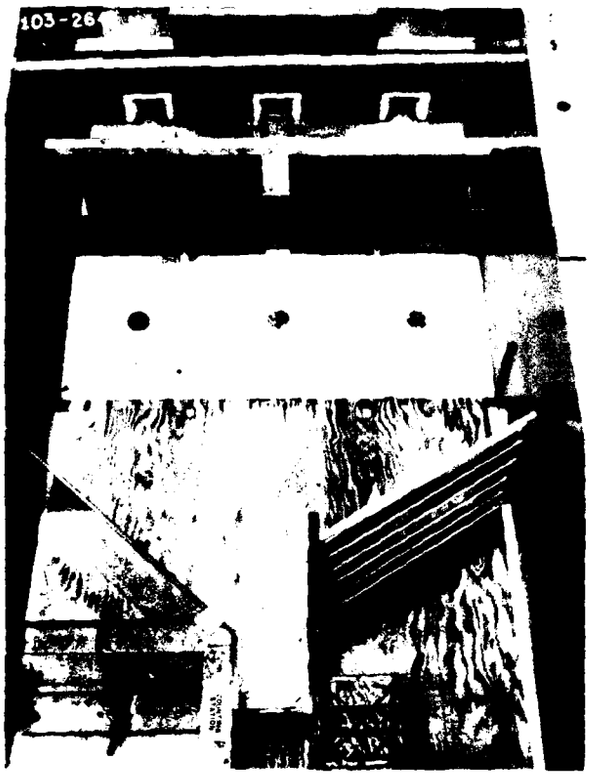


Looking upstream



Flow with 12-inch head on weirs

Photograph 19. South shore counting station with weir 194 removed.

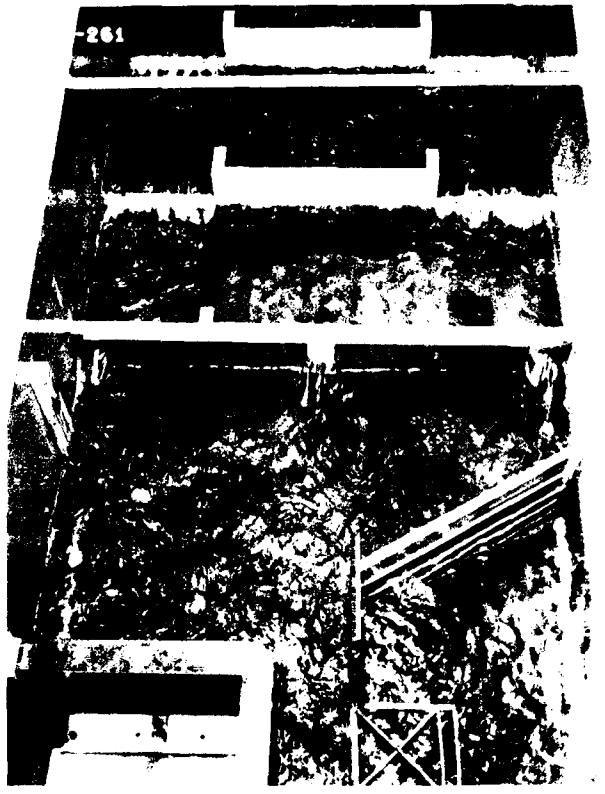


Looking upstream

Flow with 12-inch head on weirs

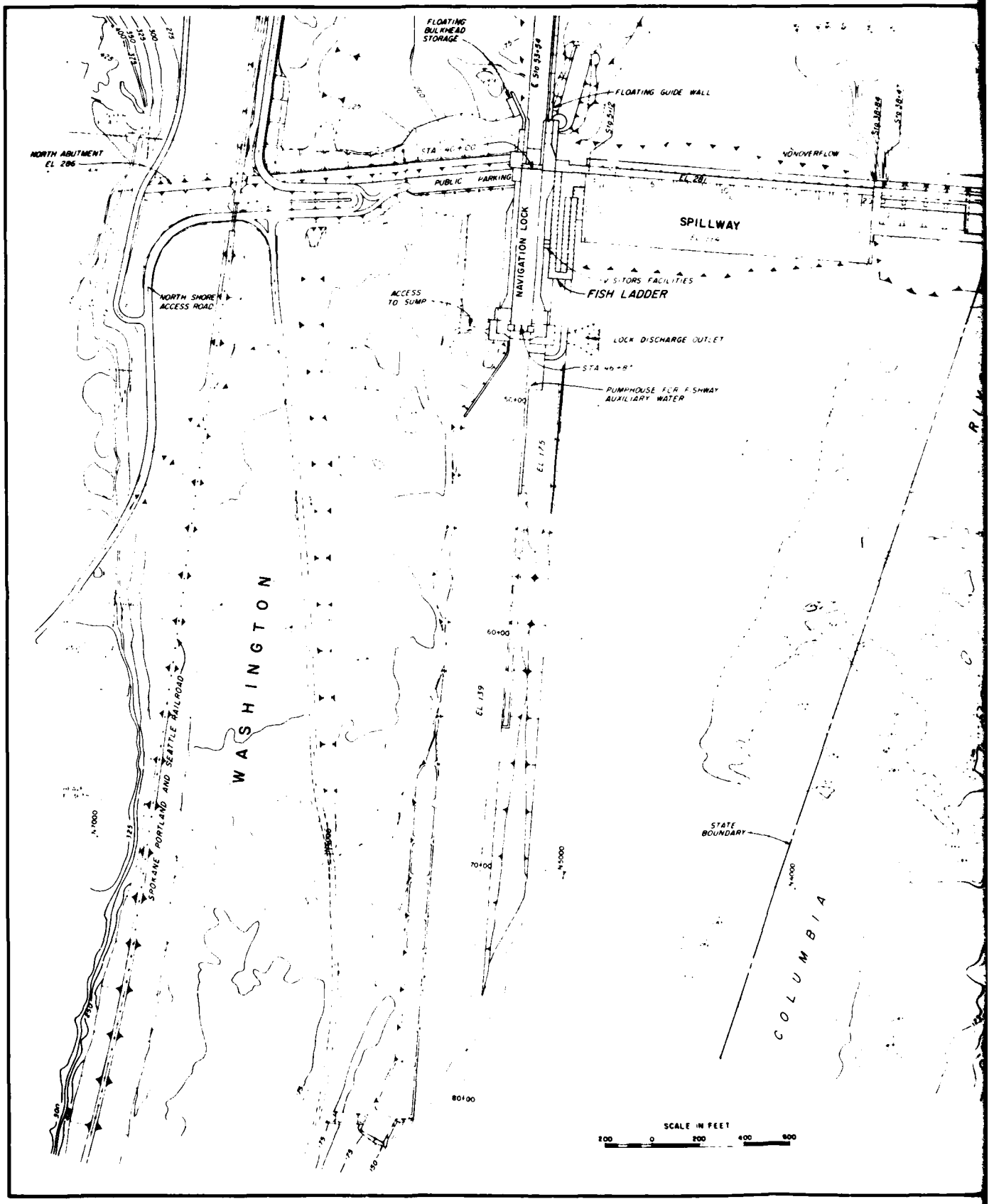
Photograph 20. South shore counting station with modified weir 195 and weir 194 removed.

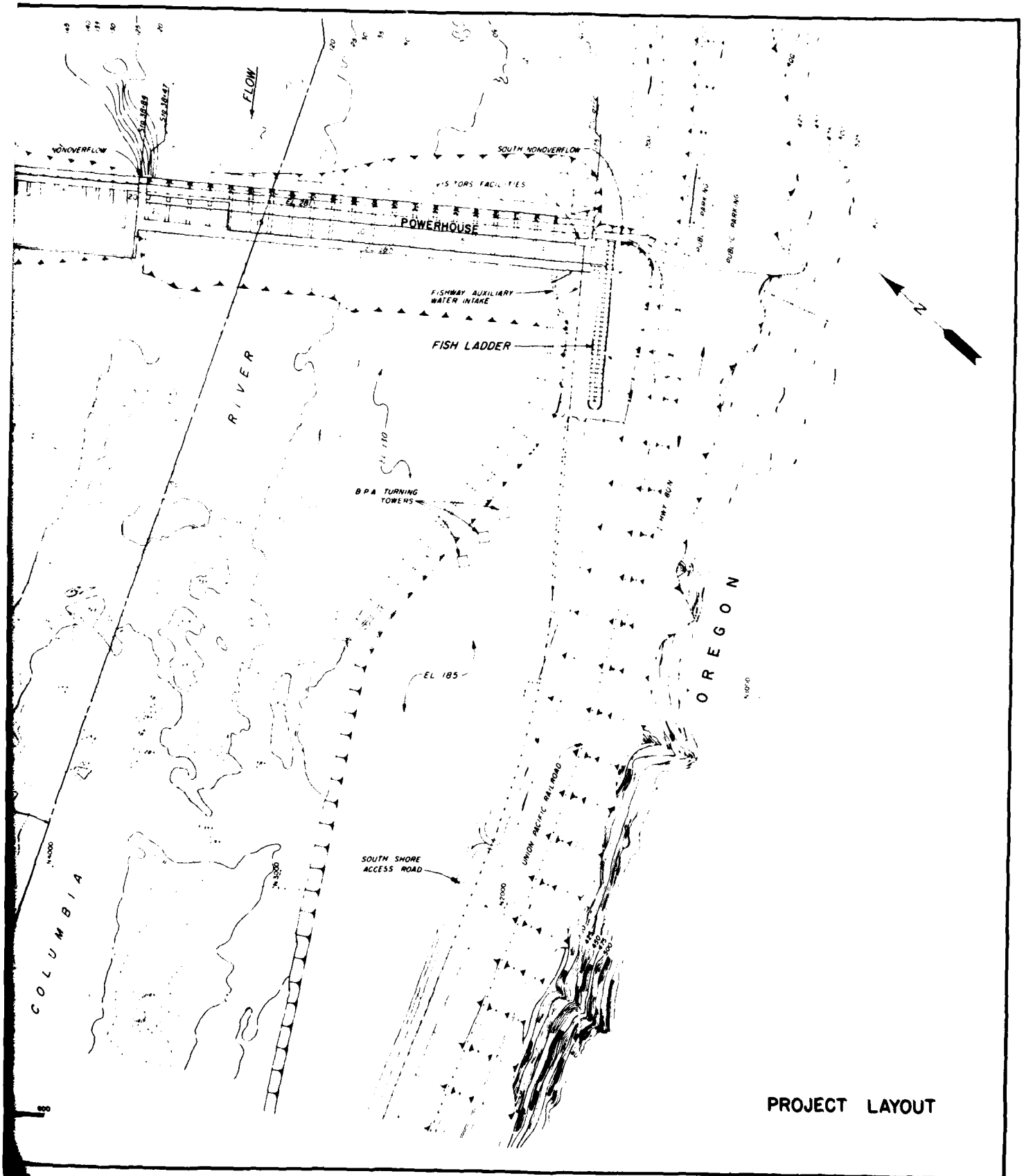
Looking upstream



Flow with 12-inch head on weirs

Photograph 21. South shore counting station with plan B modified weir 194.

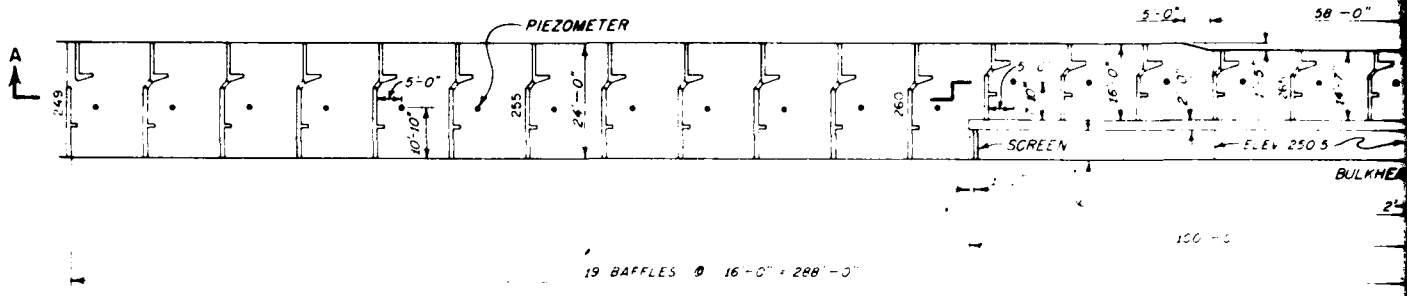

FLOATING BULKHEAD STORAGE
FLOATING GUIDE WALL
NORTH ABUTMENT EL 286
PUBLIC PARKING
NONOVERFLOW
EL 281
SPILLWAY
NAVIGATION LOCK
VISITORS FACILITIES
FISH LADDER
NORTH SHORE ACCESS ROAD
ACCESS TO SUMP
LOCK DISCHARGE OUTLET
PUMPHOUSE FOR F.SHWAY AUXILIARY WATER
EL 175
EL 139
WASHINGTON
SPOKANE PORTLAND AND SEATTLE RAILROAD
STATE BOUNDARY
COLUMBIA
SCALE IN FEET
200 0 200 400 600



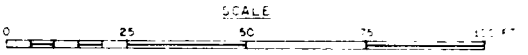
PROJECT LAYOUT

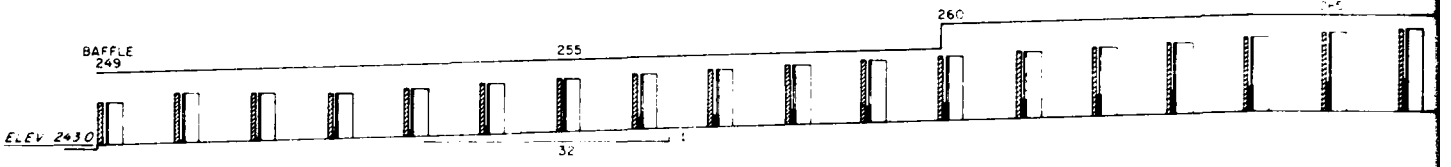
PLATE 1

2

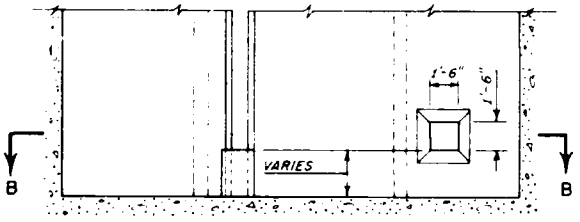


PLAN

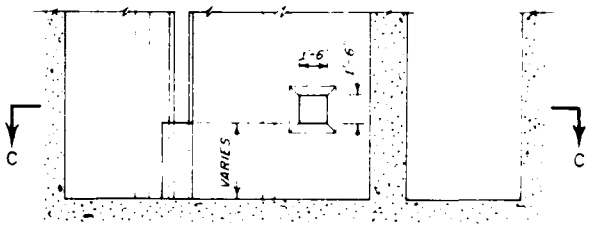




SECTION A-A

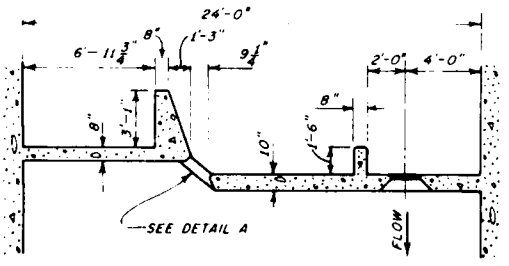


BAFFLES 249 TO 260

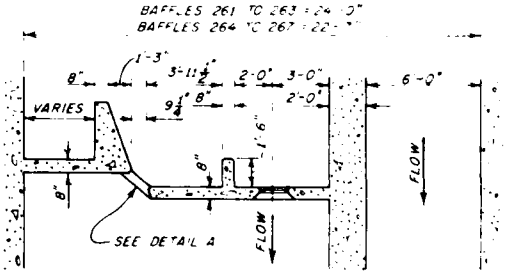


BAFFLES 261 TO 267

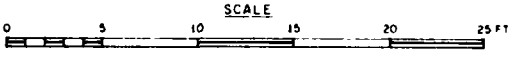
DOWNSTREAM ELEVATIONS

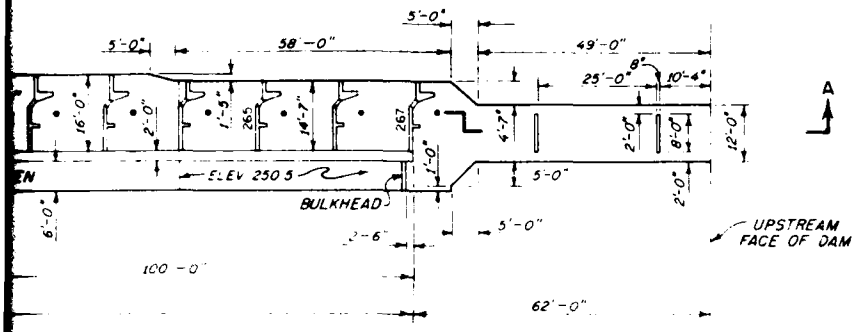


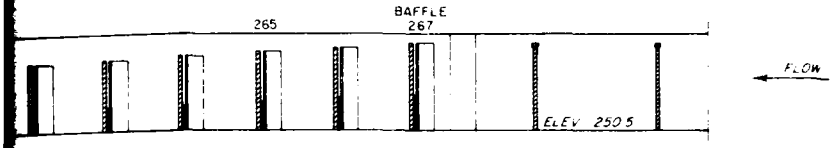
SECTION B-B



SECTION C-C

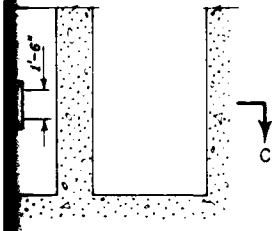




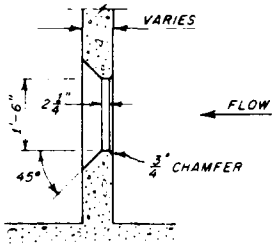


SLOT DETAILS

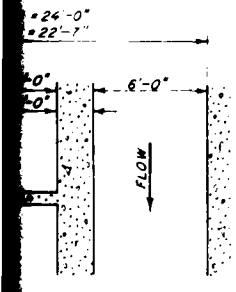
BAFFLE NO.	SLOT SILL HEIGHT	SLOT WIDTH
249		1'-7"
250	0'-4"	1'-6"
251	0'-8"	1'-6"
252	1'-0"	1'-6"
253	1'-4"	1'-6"
254	1'-8"	1'-5"
255	2'-0"	1'-4"
256	2'-4"	1'-4"
257	2'-8"	1'-4"
258	3'-0"	1'-4"
259	3'-4"	1'-3"
260	3'-8"	1'-3"
261	4'-0"	1'-3"
262	4'-4"	1'-3"
263	4'-8"	1'-3"
264	5'-0"	1'-3"
265	5'-4"	1'-3"
266	6'-8"	1'-3"
267	7'-6"	1'-3"



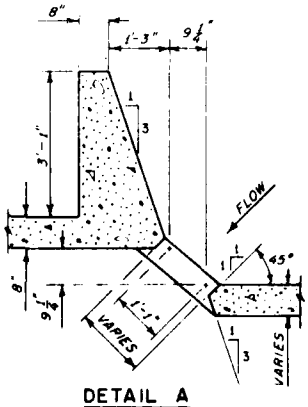
TO 267



TYPICAL ORIFICE



-C



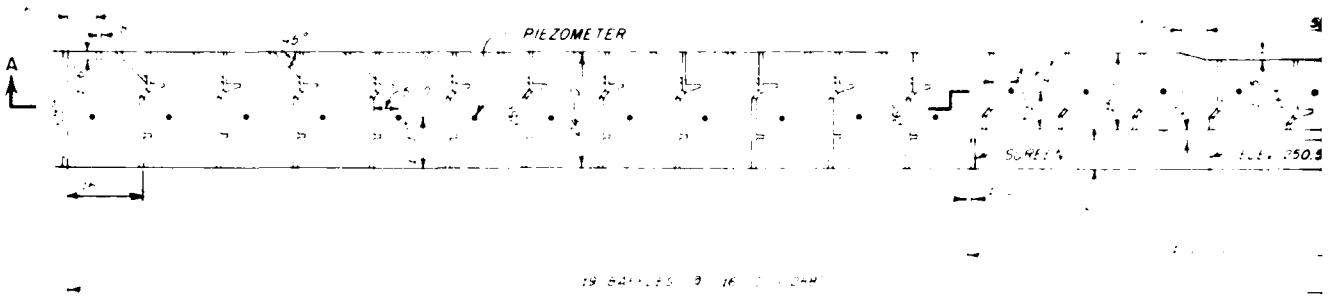
DETAIL A

SCALE
0 1 2 3 4 5 FT

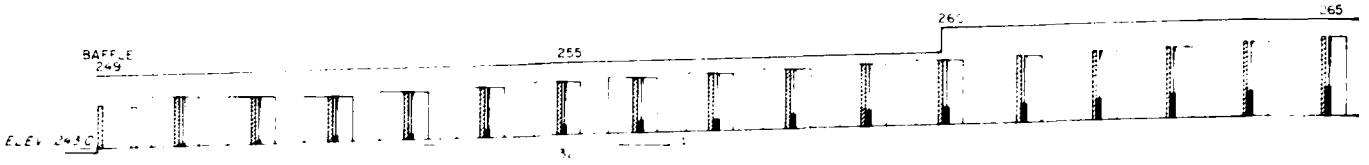
REGULATING SECTION
SLOT-ORIFICE PLAN A
NORTH SHORE FISH LADDER

PLATE 2

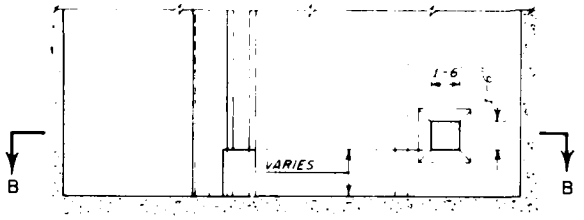
2



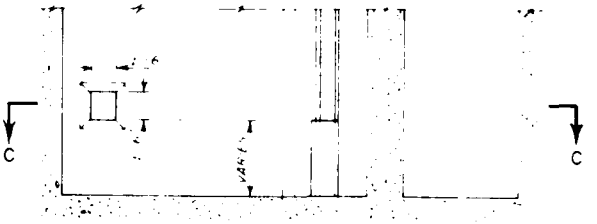
PLAN



SECTION A-A

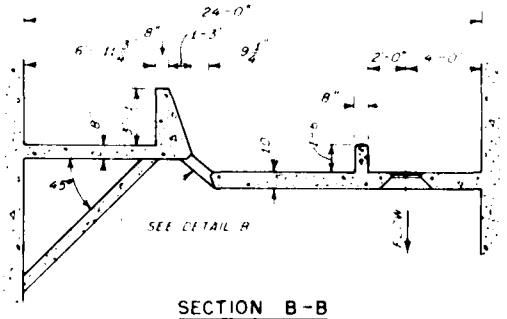


BAFFLES 250 TO 260

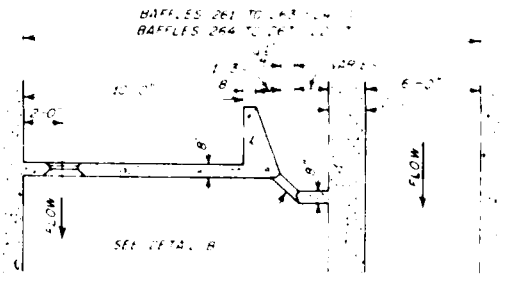


BAFFLES 261 TO 267

DOWNSTREAM ELEVATIONS

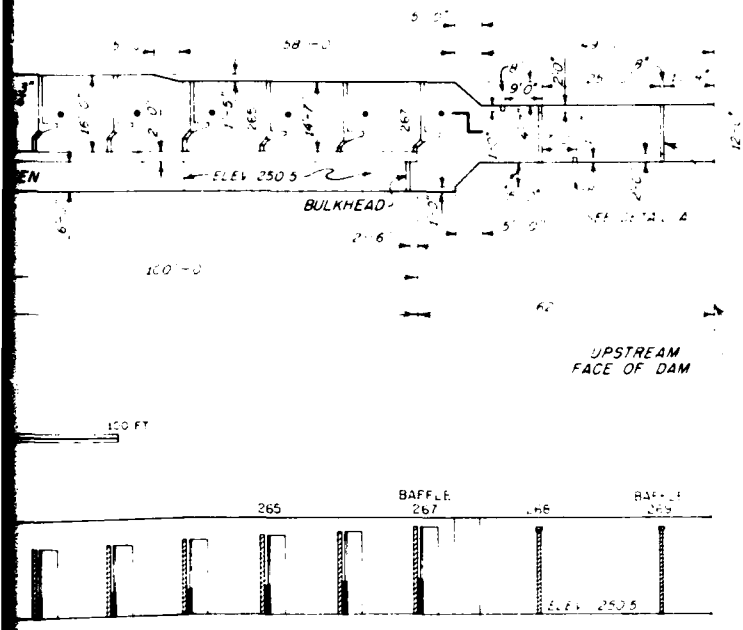


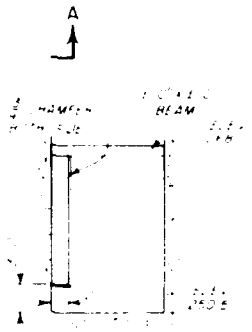
SECTION B-B



SECTION C-C

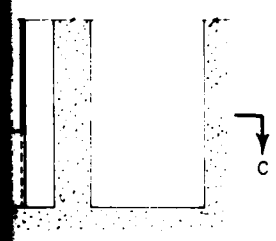
SCALE



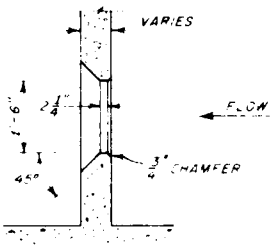


SLOT DETAILS

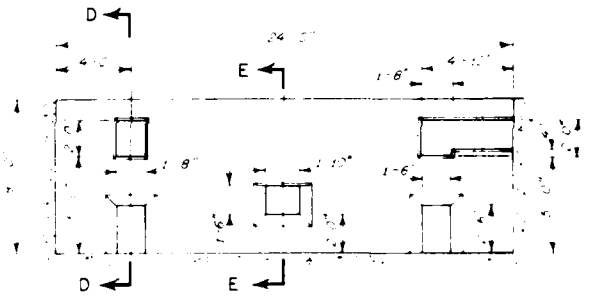
BAFFLE NO.	SLOT SILL HEIGHT	SLOT WIDTH
250		1 -
251		1 - 8
252		1 - 7
253		1 - 6
254		1 - 5
255		1 - 4
256		1 - 4
257		1 - 4
258		1 - 4
259		1 - 3
260		1 - 3
261		1 - 3
262		1 - 3
263		1 - 3
264		1 - 3
265		1 - 3
266		1 - 3
267		1 - 3
268		2 - 0
269		2 - 0



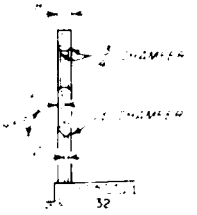
TO 267



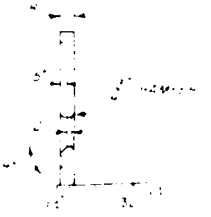
TYPICAL ORIFICE



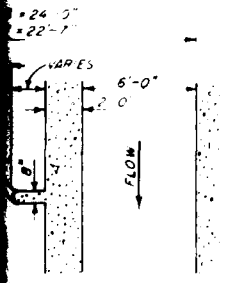
BAFFLE 249



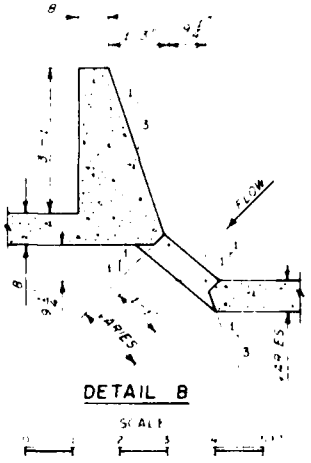
SECTION D-D



SECTION E-E



C-C



DETAIL B

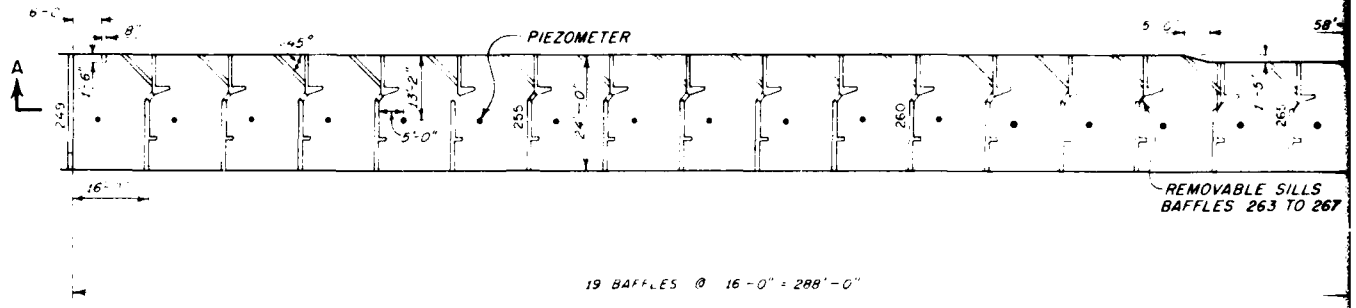
SCALE

REGULATING SECTION

SLOT-ORIFICE PLAN B

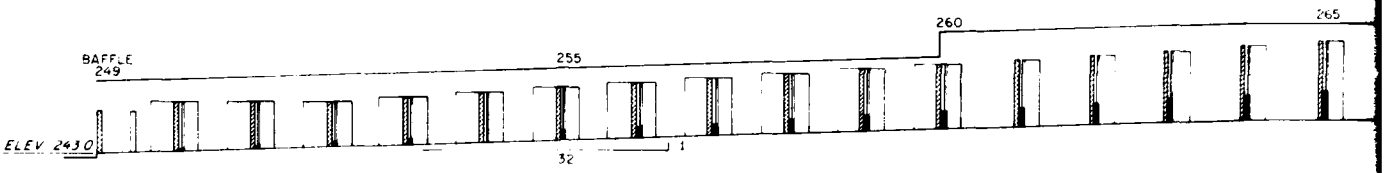
NORTH SHORE FISH LADDER

PLATE 3

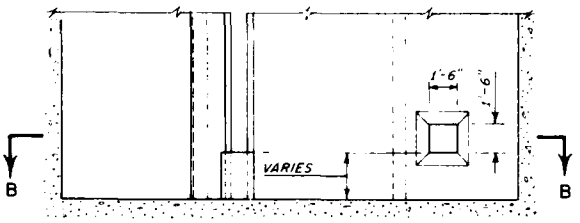


PLAN

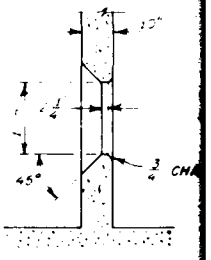
SCALE



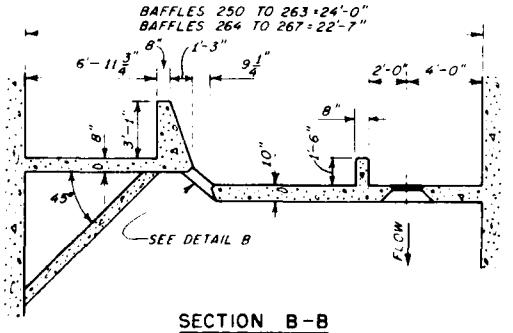
SECTION A-A



BAFFLES 250 TO 267

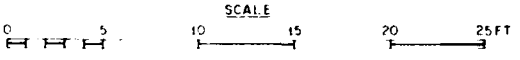


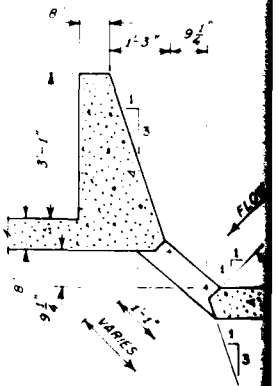
TYPICAL ORIFICE



SECTION B-B

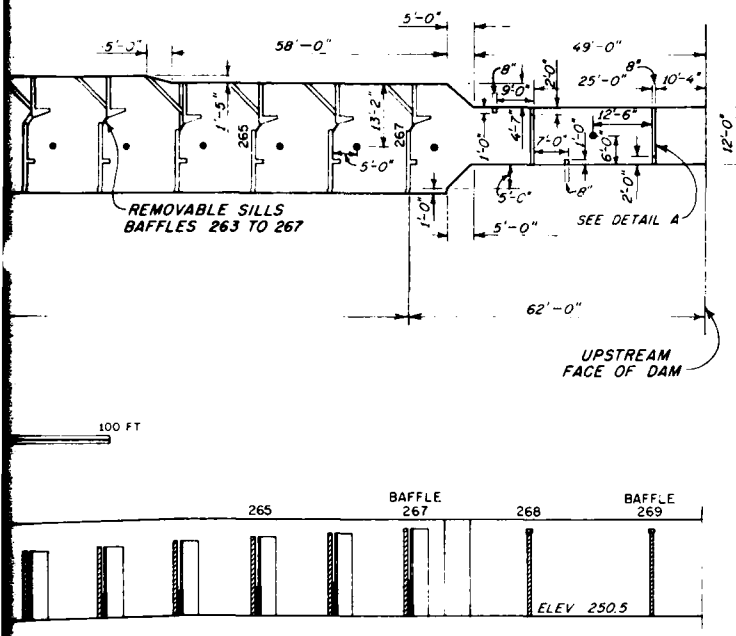
SCALE

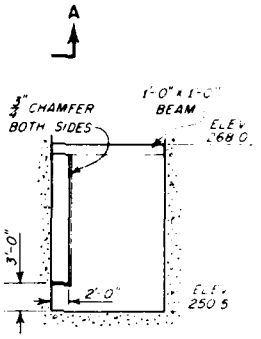




DETAIL B

SCALE

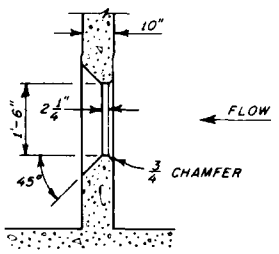




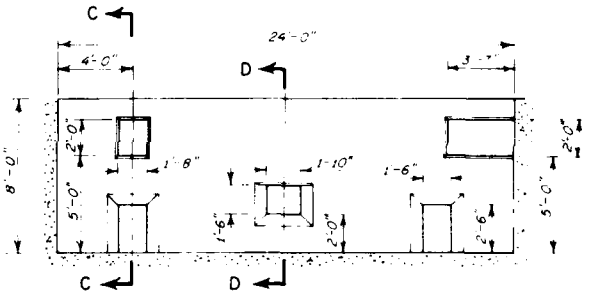
DETAIL A

SLOT DETAILS

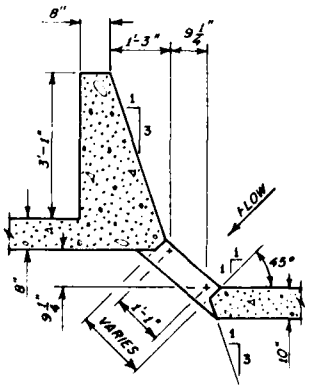
BAFFLE NO.	SLOT SILL HEIGHT	SLOT WIDTH
250	0'-6"	1'-6"
251	0'-8"	1'-8"
252	0'-8"	1'-7"
253	0'-11"	1'-6"
254	NOT SLOTTED	1'-5"
255	1'-1"	1'-5"
256	1'-2"	1'-4"
257	1'-7"	1'-4"
258	2'-1"	1'-4"
259	2'-1"	1'-3"
260	2'-8"	1'-3"
261	3'-1"	1'-3"
262	3'-2"	1'-3"
263	3'-8"	1'-3"
264	4'-2"	1'-3"
265	5'-4"	1'-3"
266	6'-2"	1'-3"
267	7'-3"	1'-3"
268	3'-0"	2'-0"
269	3'-0"	2'-0"



TYPICAL ORIFICE

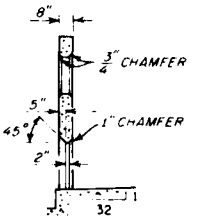


BAFFLE 249

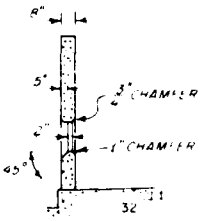


DETAIL B

SCALE
0 1 2 3 4 5 FT



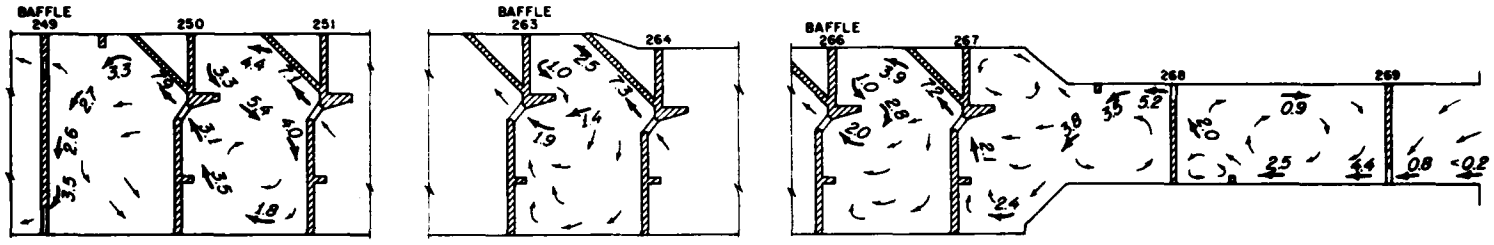
SECTION C-C



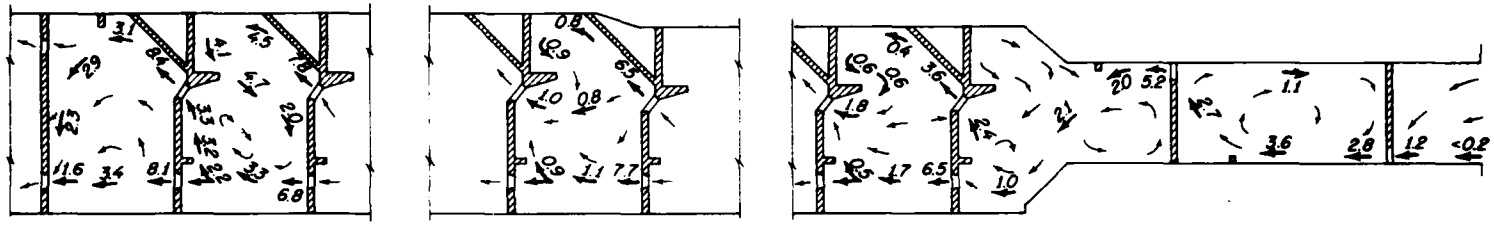
SECTION D-D

REGULATING SECTION
SLOT-ORIFICE PLAN C
NORTH SHORE FISH LADDER

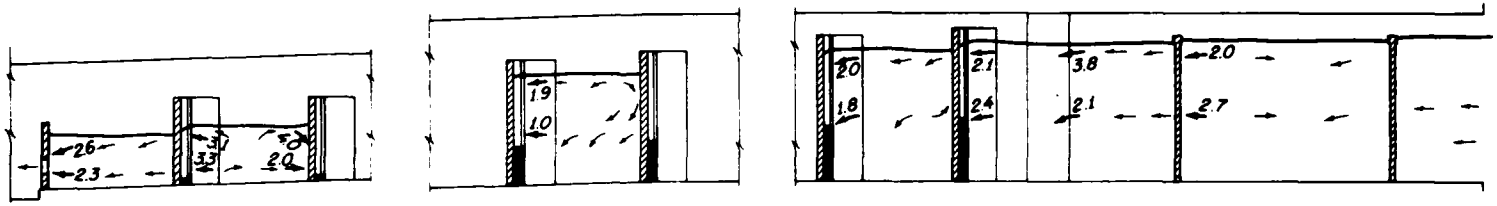
PLATE 4



1 FT BELOW WATER SURFACE



CENTER LINE OF ORIFICE



CENTER LINE OF LADDER

NOTES

1 VELOCITIES MEASURED WITH MIDGET CURRENT METER, METER AXIS HORIZONTAL

2 BAFFLE DETAILS SHOWN ON PLATE 4.

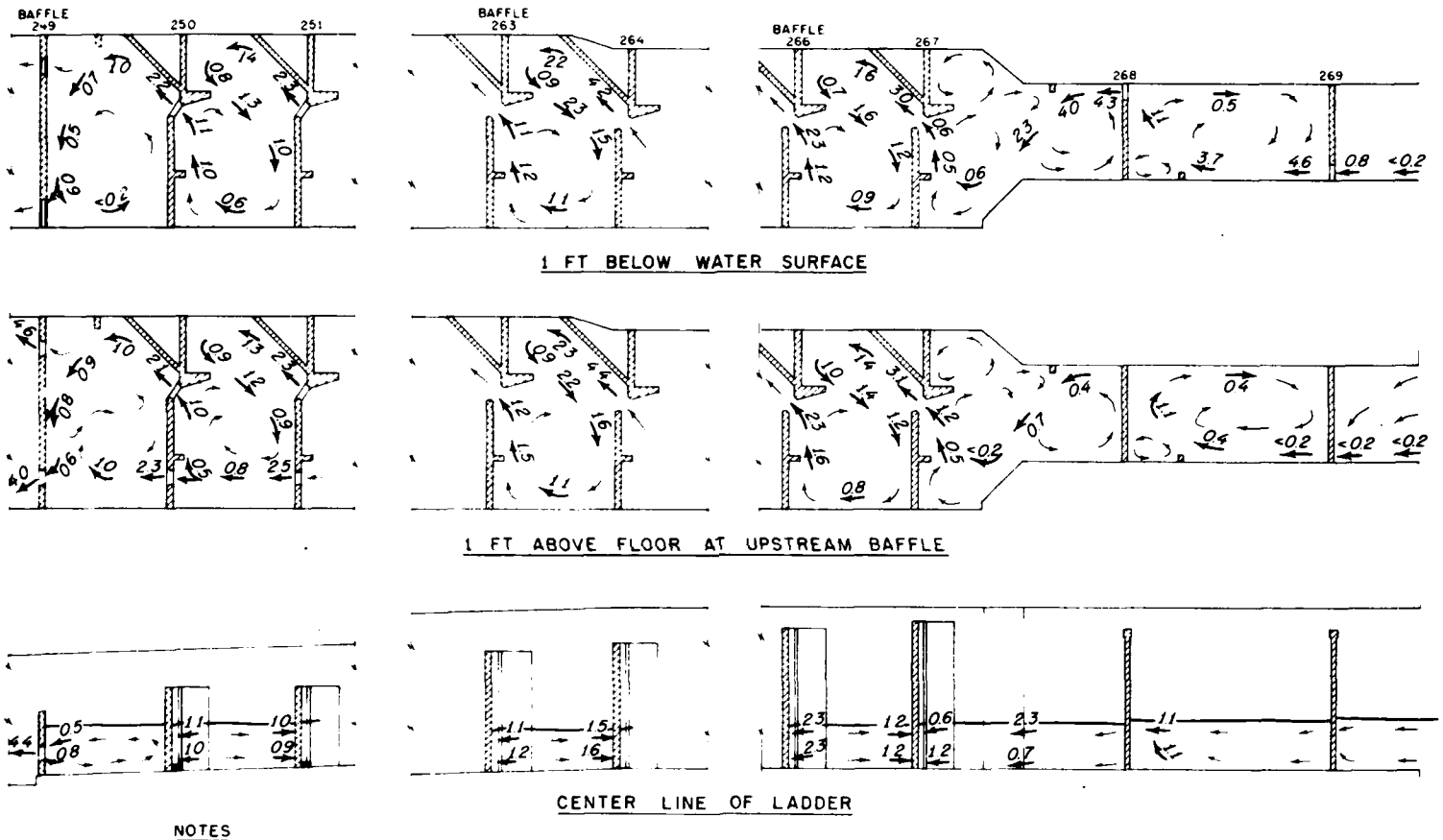
FOREBAY ELEV 268
SLOT AND ORIFICE FLOW
DISCHARGE 85.0 CFS

VELOCITIES

REGULATING SECTION, SLOT-ORIFICE PLAN C
NORTH SHORE FISH LADDER

PLATE 5 A

PLATE 58



NOTES

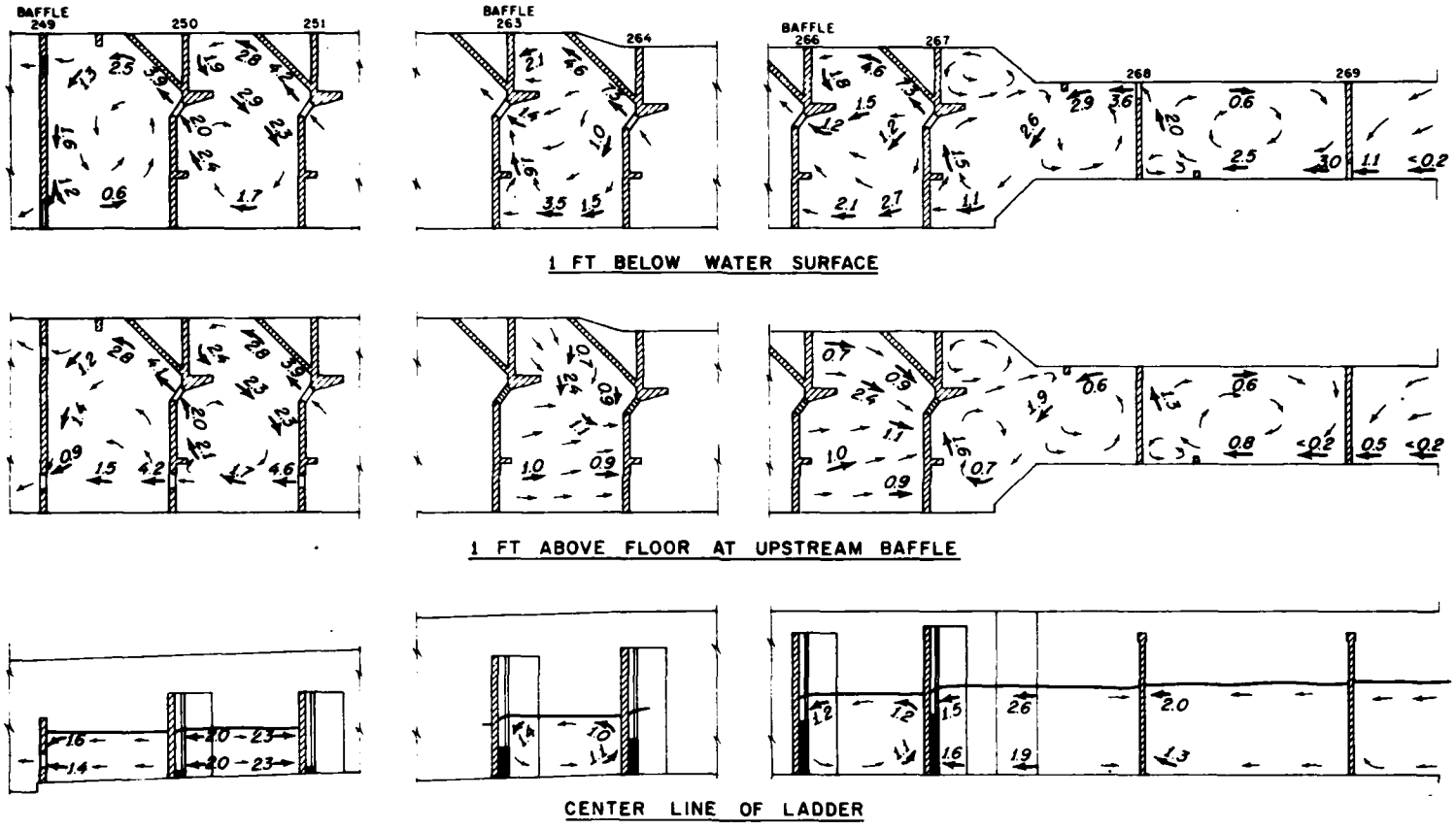
1 VELOCITIES MEASURED WITH MIDGET CURRENT METER, METER AXIS HORIZONTAL

2 BAFFLE DETAILS SHOWN ON **PLATE 4.**

FOREBAY ELEV 257
SLOT AND ORIFICE FLOW
DISCHARGE 18.9 CFS
LADDER DISCHARGE 82.2 CFS

VELOCITIES

REGULATING SECTION, SLOT-ORIFICE PLAN C
NORTH SHORE FISH LADDER



NOTES

1 VELOCITIES MEASURED WITH MIDGET CURRENT METER, METER AXIS HORIZONTAL

2 BAFFLE DETAILS SHOWN ON PLATE 4.

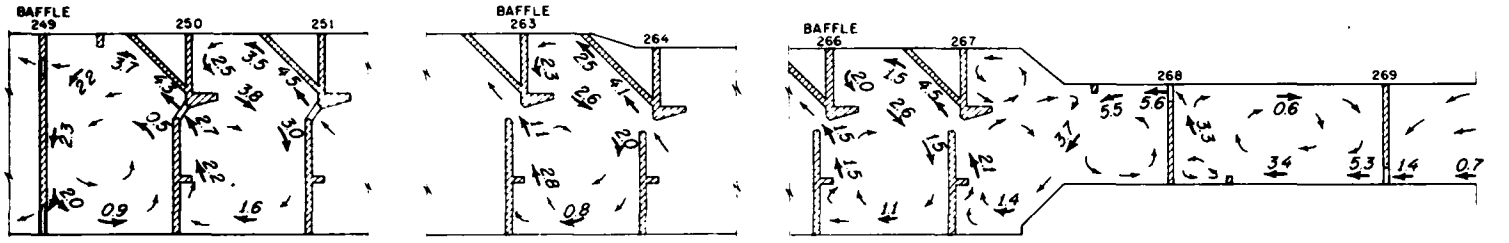
FOREBAY ELEV 262
SLOT AND ORIFICE FLOW
REMOVABLE SILLS IN
DISCHARGE 37.8 CFS
LADDER DISCHARGE 82.2 CFS

VELOCITIES

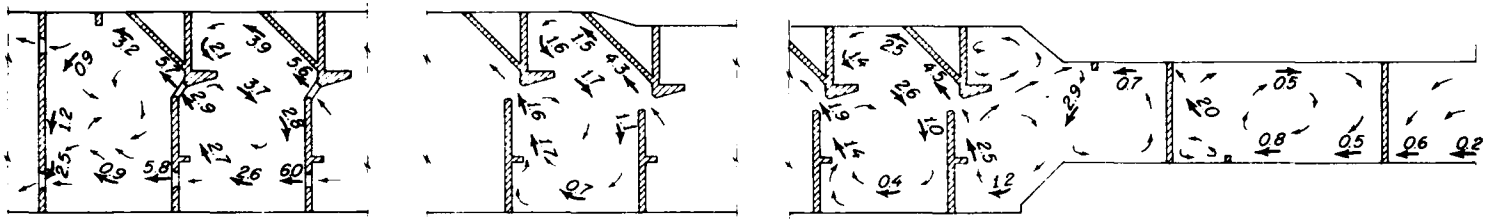
REGULATING SECTION, SLOT-ORIFICE PLAN C
NORTH SHORE FISH LADDER

PLATE 6A

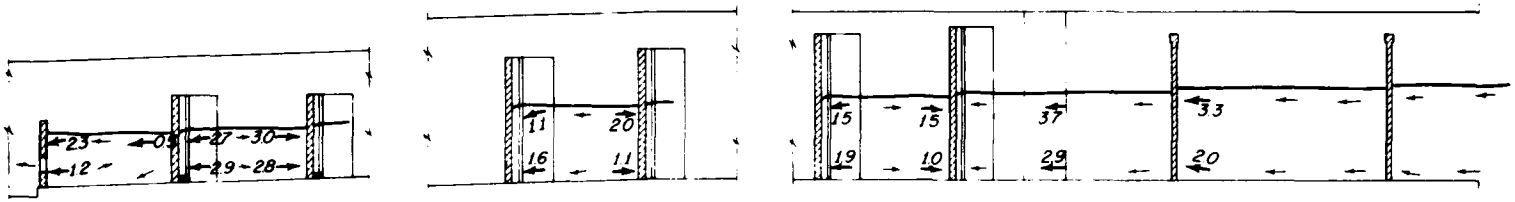
PLATE 6B



1 FT BELOW WATER SURFACE



1 FT ABOVE FLOOR AT UPSTREAM BAFFLE



CENTER LINE OF LADDER

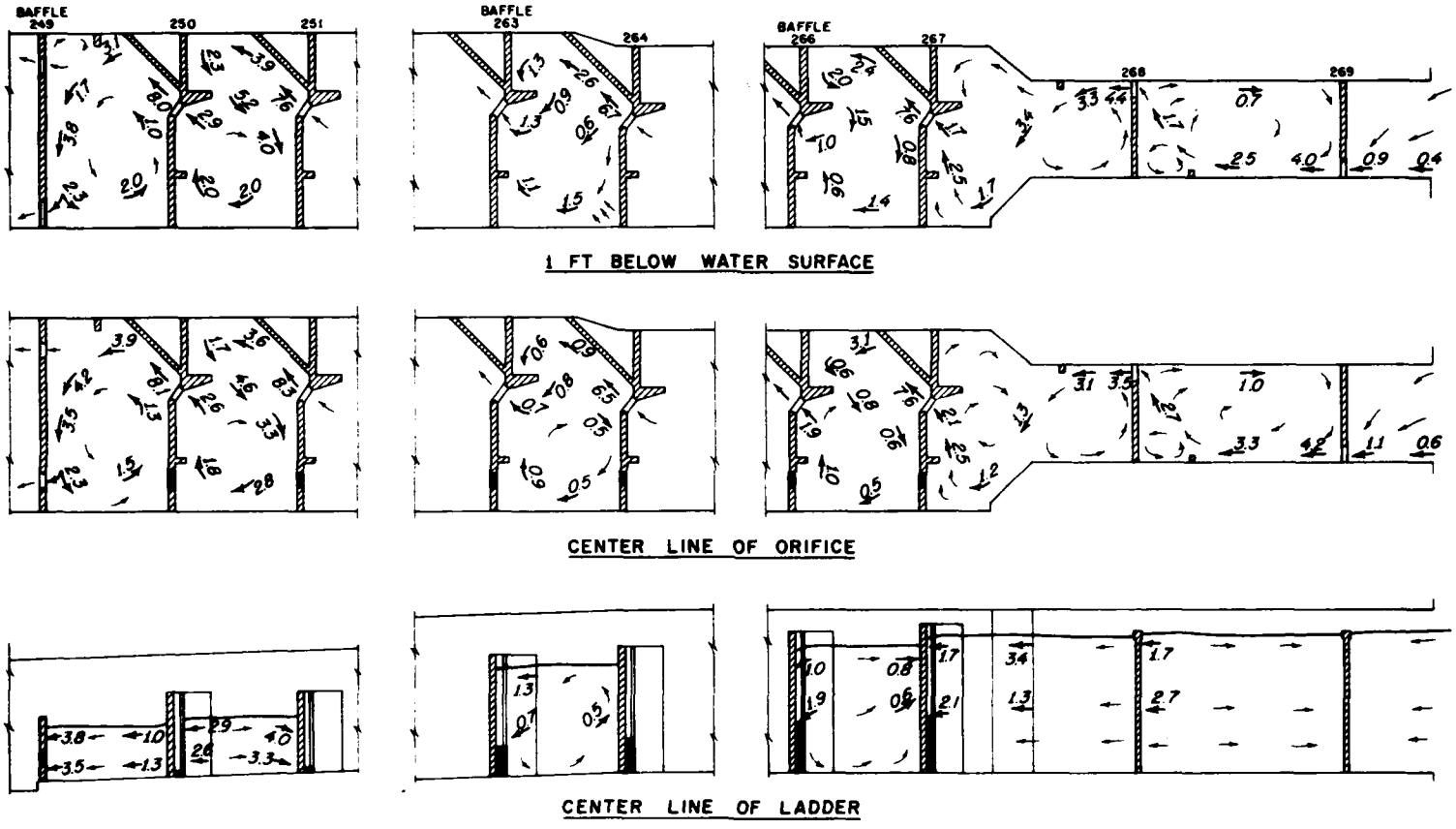
NOTES

1. VELOCITIES MEASURED WITH MIDGET CURRENT METER, METER AXIS HORIZONTAL
2. BAFFLE DETAILS SHOWN ON **PLATE 4**.

FOREBAY ELEV 262
SLOT AND ORIFICE FLOW
REMOVABLE SILLS OUT
DISCHARGE 54.7 CFS
LADDER DISCHARGE 82.2 CFS

VELOCITIES

REGULATING SECTION, SLOT-ORIFICE PLAN C
NORTH SHORE FISH LADDER



NOTES

1 VELOCITIES MEASURED WITH MIDGET CURRENT METER, METER AXIS HORIZONTAL
2 LADDER DISCHARGE 82 2 CFS
3 BAFFLE DETAILS SHOWN ON PLATE 4.
4 SIDE ORIFICES OF BAFFLE 249 OPEN, CENTER ORIFICE CLOSED

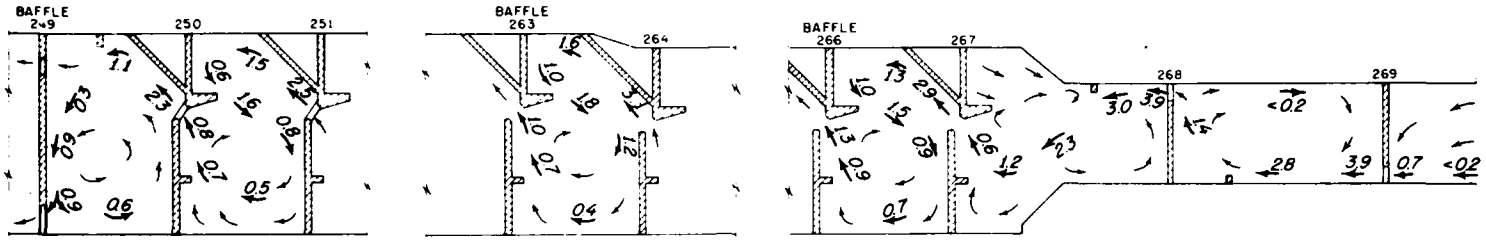
SLOT FLOW ONLY
DISCHARGE 72.4 CFS

VELOCITIES

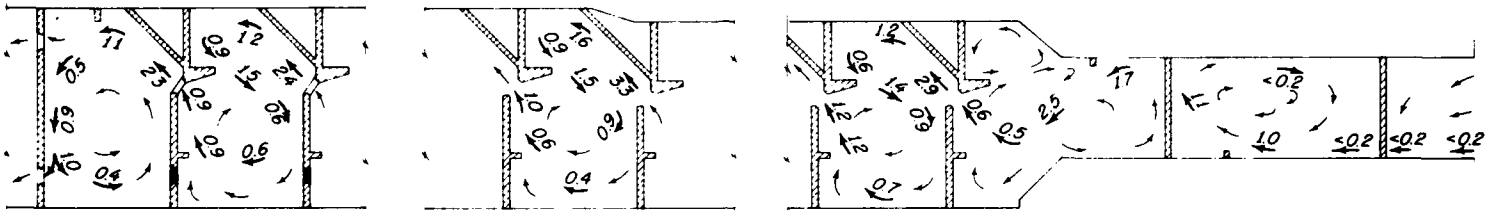
REGULATING SECTION, SLOT-ORIFICE PLAN C
NORTH SHORE FISH LADDER
FOREBAY ELEV 268

PLATE 7A

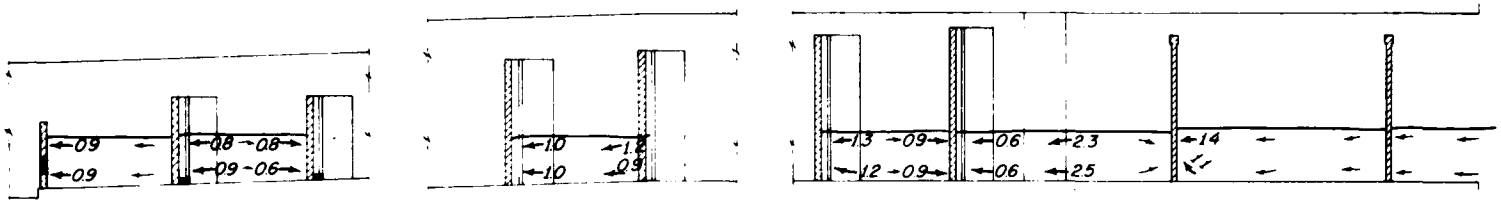
PLATE 7B



1 FT BELOW WATER SURFACE



1 FT ABOVE FLOOR AT UPSTREAM BAFFLE



CENTER LINE OF LADDER

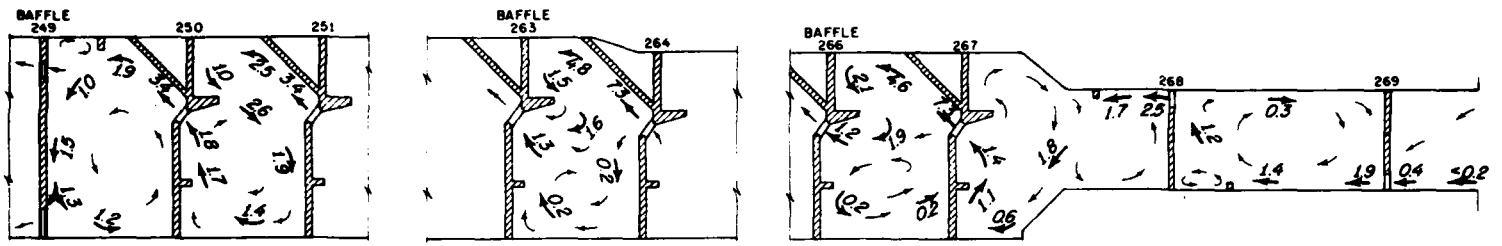
NOTES

1 VELOCITIES MEASURED WITH MIDGET CURRENT METER, METER AXIS HORIZONTAL
2 LADDER DISCHARGE 42.2 CFS
3 BAFFLE DETAILS SHOWN ON **PLATE 4.**
4 SIDE ORIFICES OF BAFFLE 249 OPEN, CENTER ORIFICE CLOSED

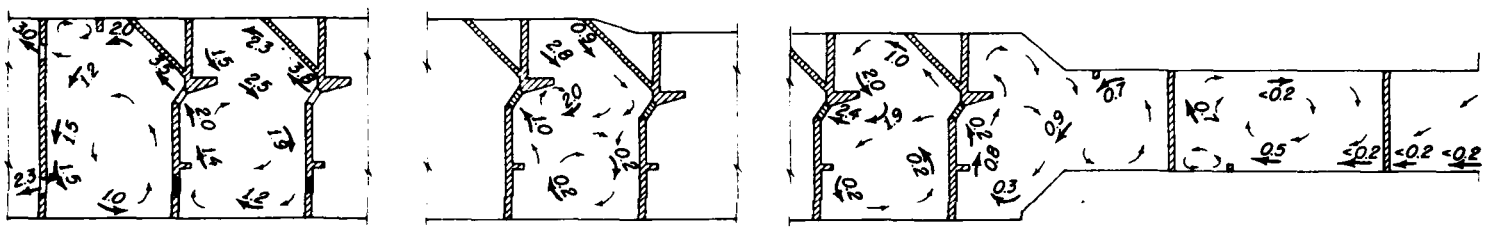
SLOT FLOW ONLY
DISCHARGE 16.3 CFS

VELOCITIES

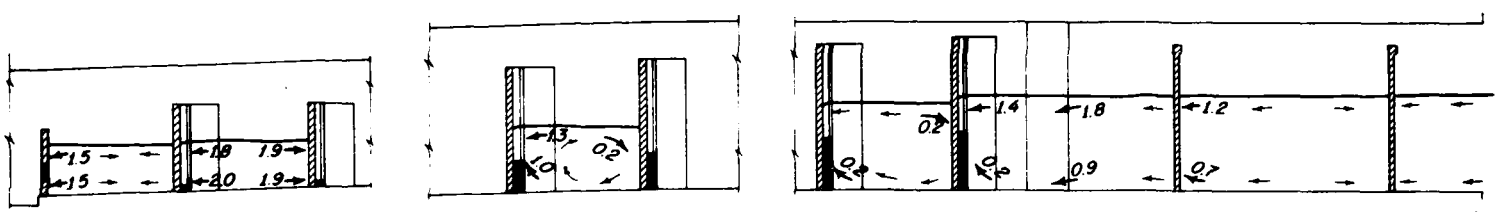
REGULATING SECTION, SLOT-ORIFICE PLAN C
NORTH SHORE FISH LADDER
FOREBAY ELEV 257



1 FT BELOW WATER SURFACE



1 FT ABOVE FLOOR AT UPSTREAM BAFFLE



CENTER LINE OF LADDER

NOTES

1 VELOCITIES MEASURED WITH MIDGET CURRENT METER, METER AXIS HORIZONTAL
2 LADDER DISCHARGE 822 CFS
3 BAFFLE DETAILS SHOWN ON **PLATE 4.**
4 SIDE ORIFICES OF BAFFLE 249 OPEN, CENTER ORIFICE CLOSED

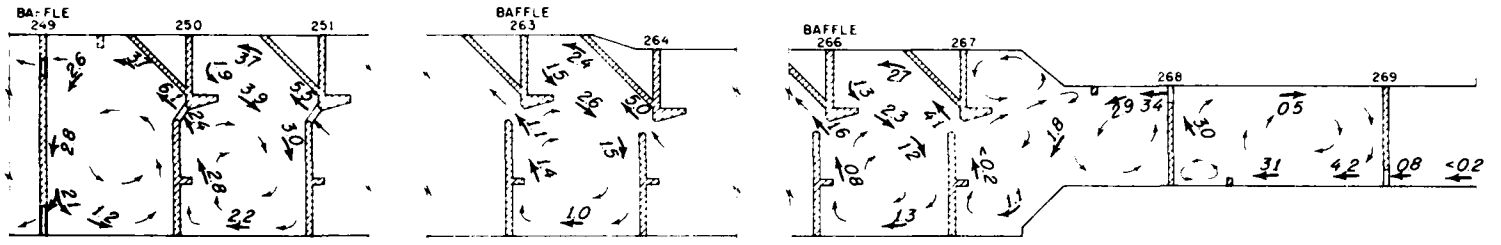
SLOT FLOW ONLY
REMOVABLE SILLS IN
DISCHARGE 25 7 CFS

VELOCITIES

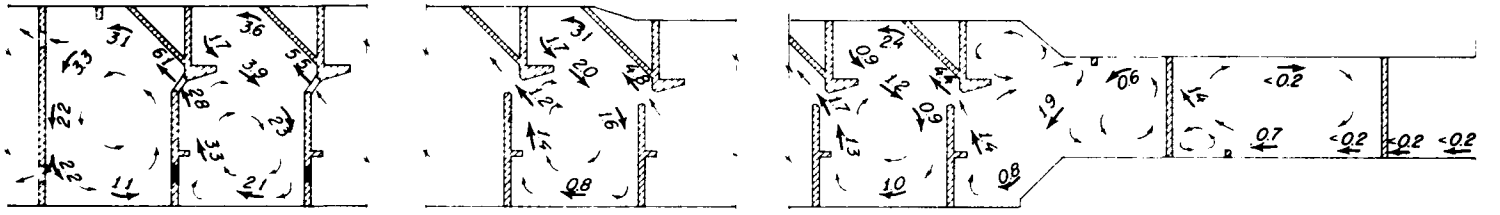
REGULATING SECTION, SLOT-ORIFICE PLAN C
NORTH SHORE FISH LADDER
FOREBAY ELEV 262

PLATE 8A

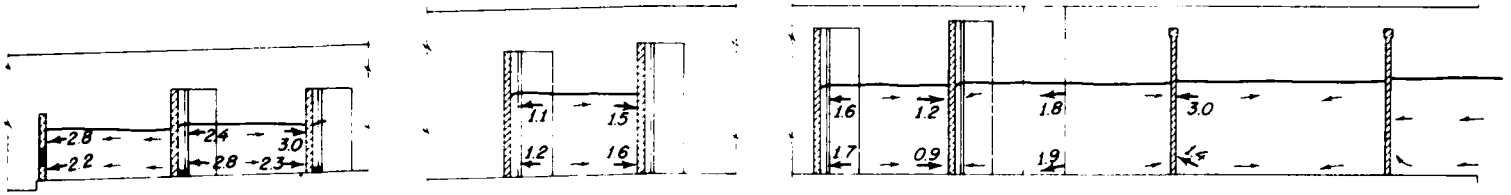
PLATE 8B



1 FT BELOW WATER SURFACE



1 FT ABOVE FLOOR AT UPSTREAM BAFFLE



CENTER LINE OF LADDER

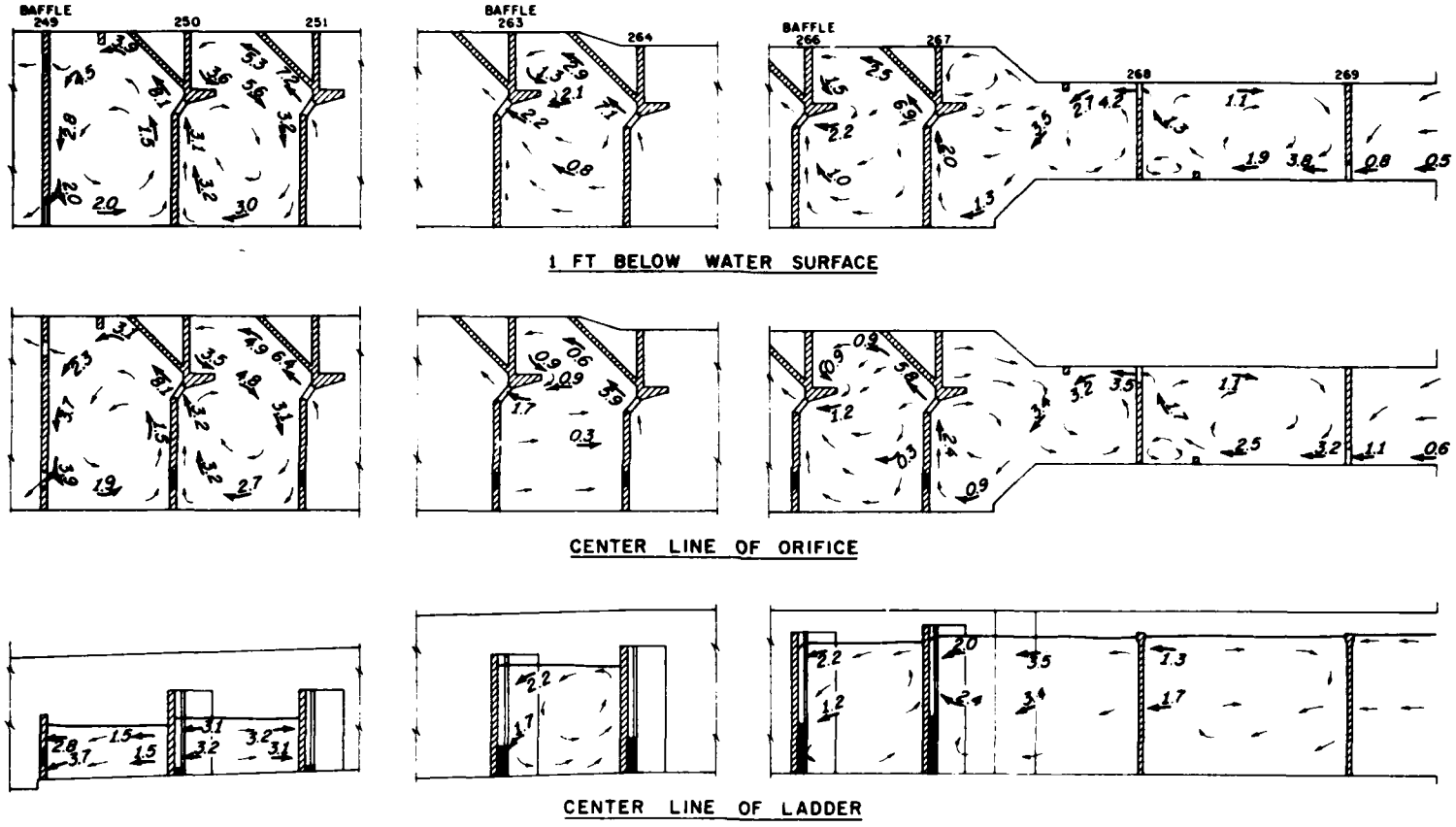
NOTES

1 VELOCITIES MEASURED WITH MIDGET CURRENT METER, METER AXIS HORIZONTAL
2 LADDER DISCHARGE 82 2 CFS
3 BAFFLE DETAILS SHOWN ON **PLATE 4**.
4 SIDE ORIFICES OF BAFFLE 249 OPEN, CENTER ORIFICE CLOSED

SLOT FLOW ONLY
REMOVABLE SILLS OUT
DISCHARGE 45 2 CFS

VELOCITIES

REGULATING SECTION, SLOT-ORIFICE PLAN C
NORTH SHORE FISH LADDER
FOREBAY ELEV 262



NOTES

1 VELOCITIES MEASURED WITH MIDGET CURRENT METER, METER AXIS HORIZONTAL
2 LADDER DISCHARGE 82.2 CFS
3 BAFFLE DETAILS SHOWN ON PLATE 4.
4 SIDE ORIFICES OF BAFFLE 249 OPEN, CENTER ORIFICE CLOSED

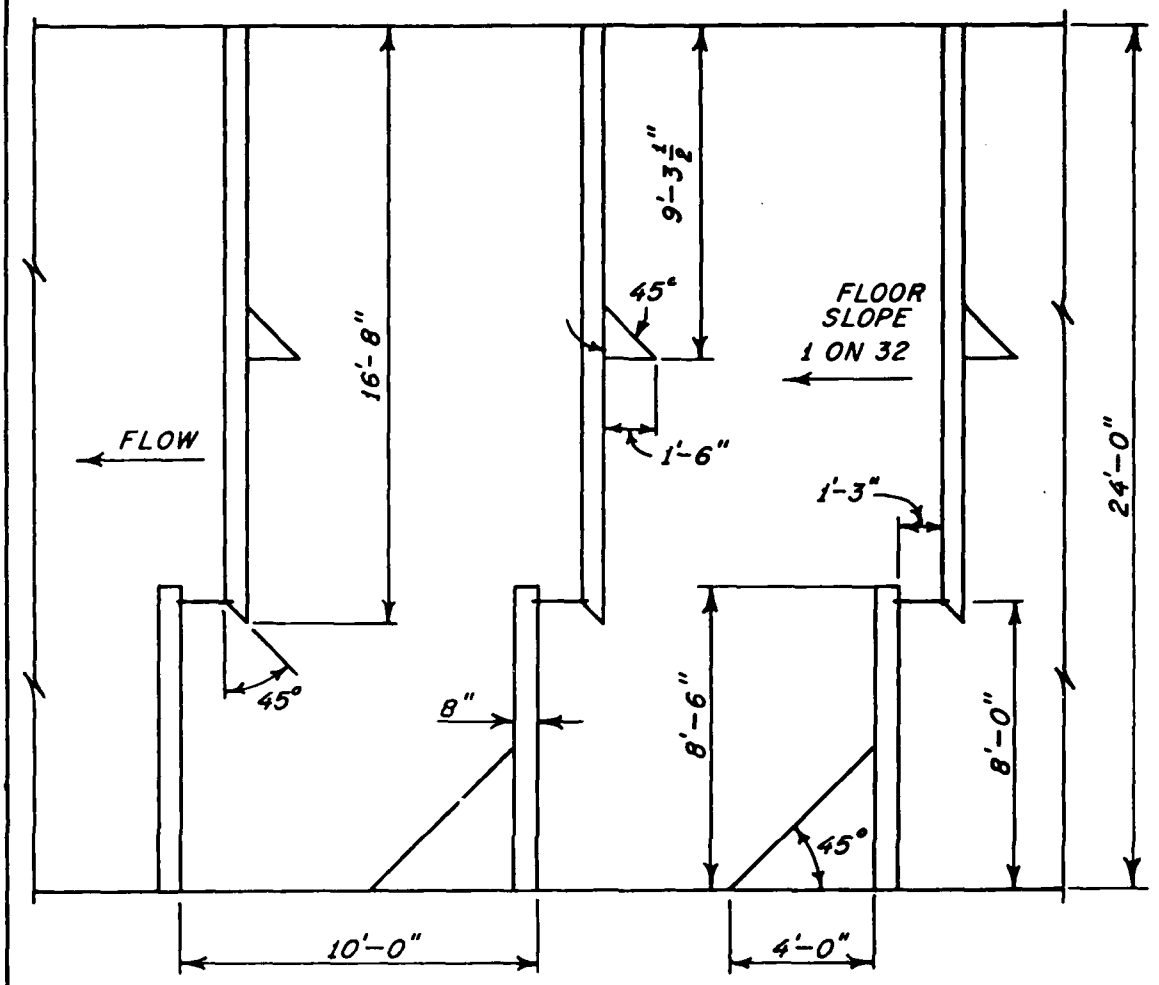
FOREBAY ELEV 268
SLOT FLOW ONLY

DISCHARGE 72.4 CFS

VELOCITIES

REGULATING SECTION, SLOT-ORIFICE PLAN C
NORTH SHORE FISH LADDER
18-INCH FINS REMOVED

PLATE 9



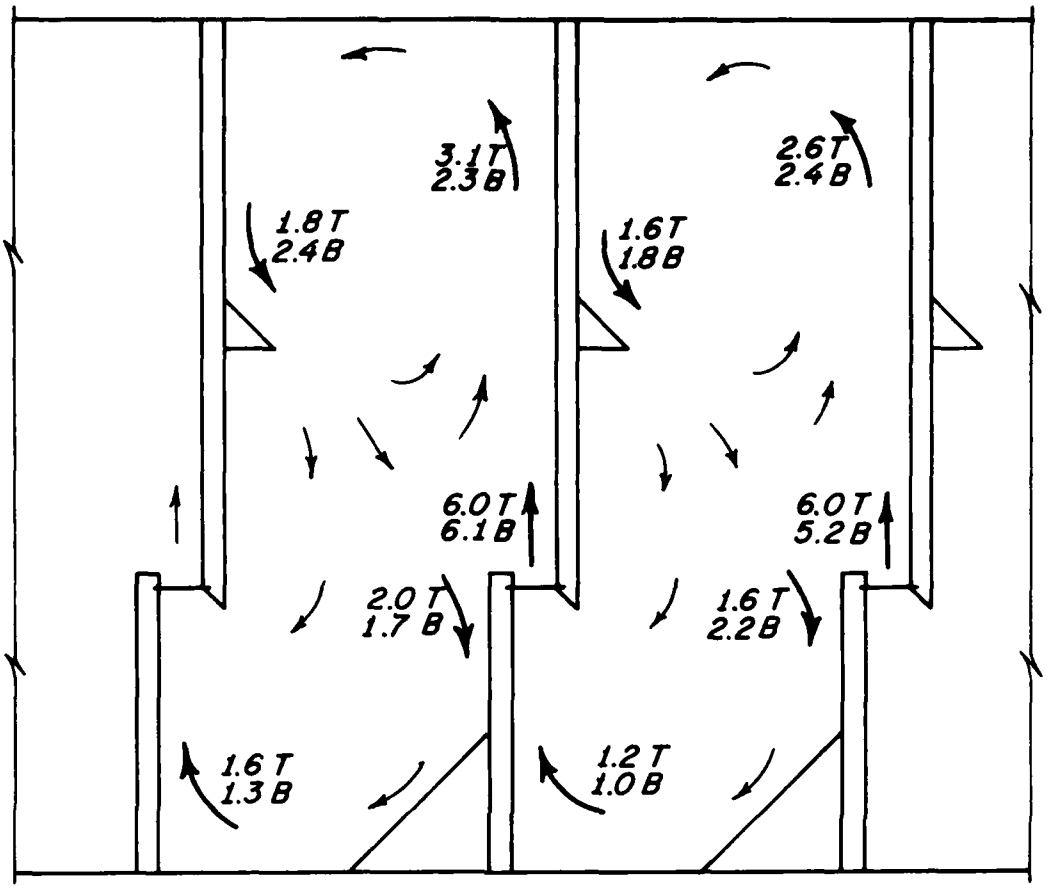
PLAN

0 5 10 FT

DETAILS

REGULATING SECTION
SLOT PLAN D
PRELIMINARY TEST POOLS
NORTH SHORE FISH LADDER

PLATE 10



NOTES

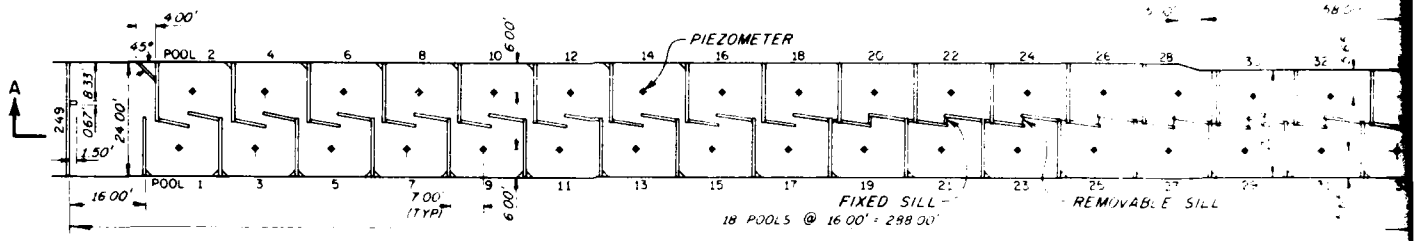
1. VELOCITIES MEASURED WITH MIDGET CURRENT METER, METER AXIS HORIZONTAL.
2. POOL AND BAFFLE DETAILS SHOWN ON PLATE 10.

LEGEND

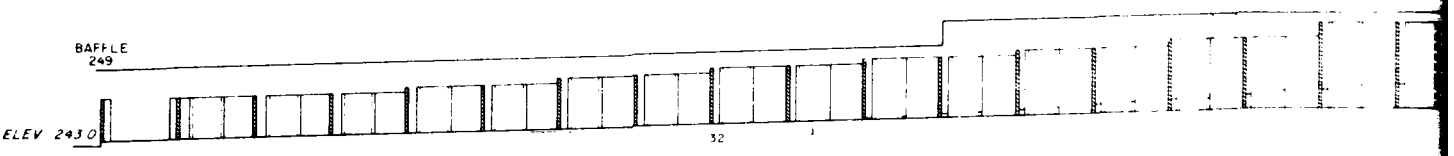
1.6 ← VELOCITY IN FPS
T 1 FT BELOW WATER SURFACE
B 1 FT ABOVE UPSTREAM SLOT SILL

VELOCITIES
8-IN. HEAD DROP
SLOT PLAN D
PRELIMINARY TEST POOLS
NORTH SHORE FISH LADDER

PLATE 11

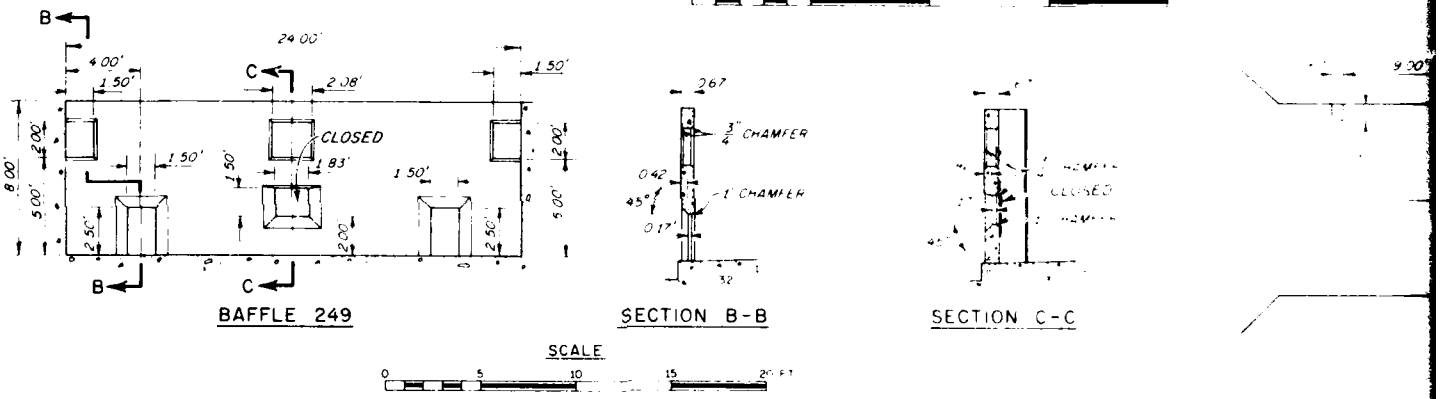


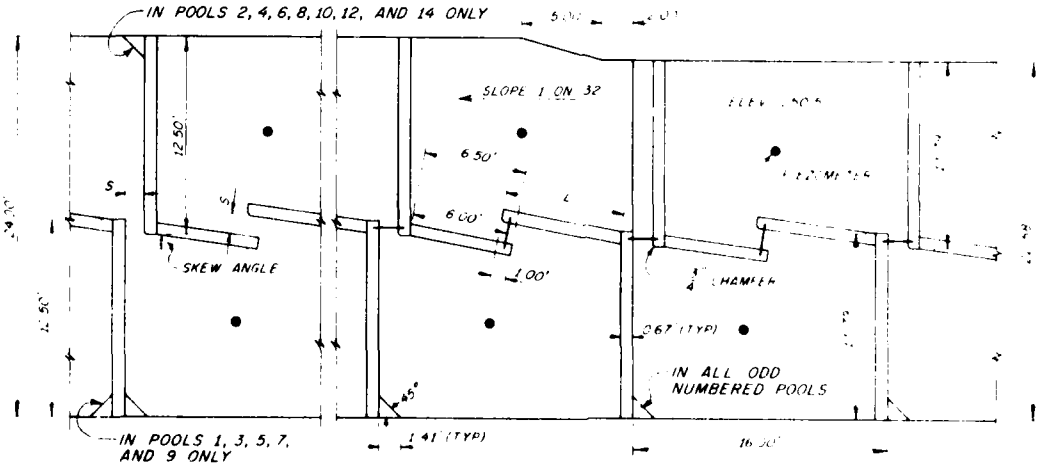
PLAN



SECTION A-A

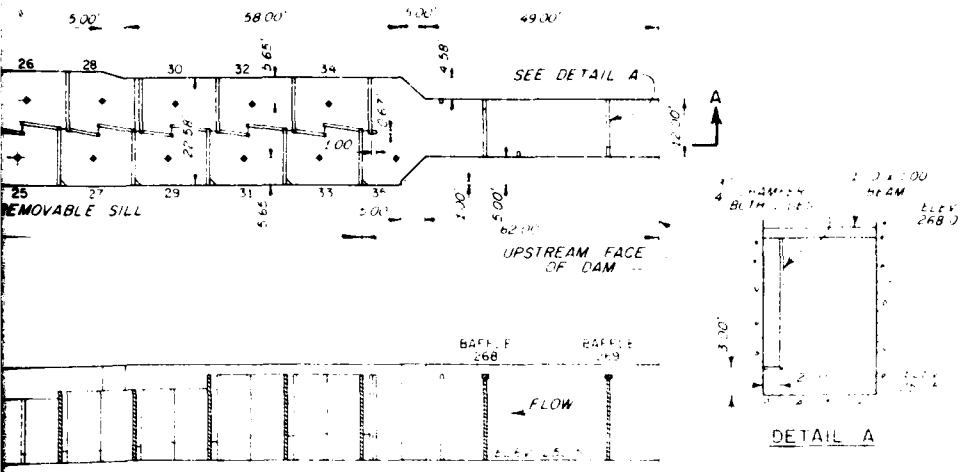
SCALE

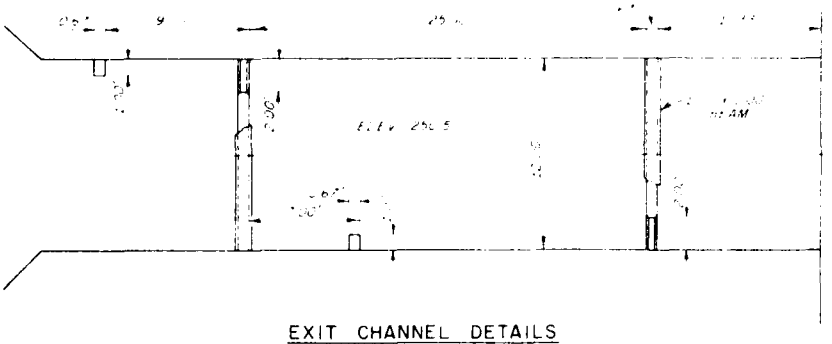




POOL DETAILS

SCALE





EXIT CHANNEL DETAILS

SCALE

0 5 10 15 20 25 FT

SLOT DETAILS

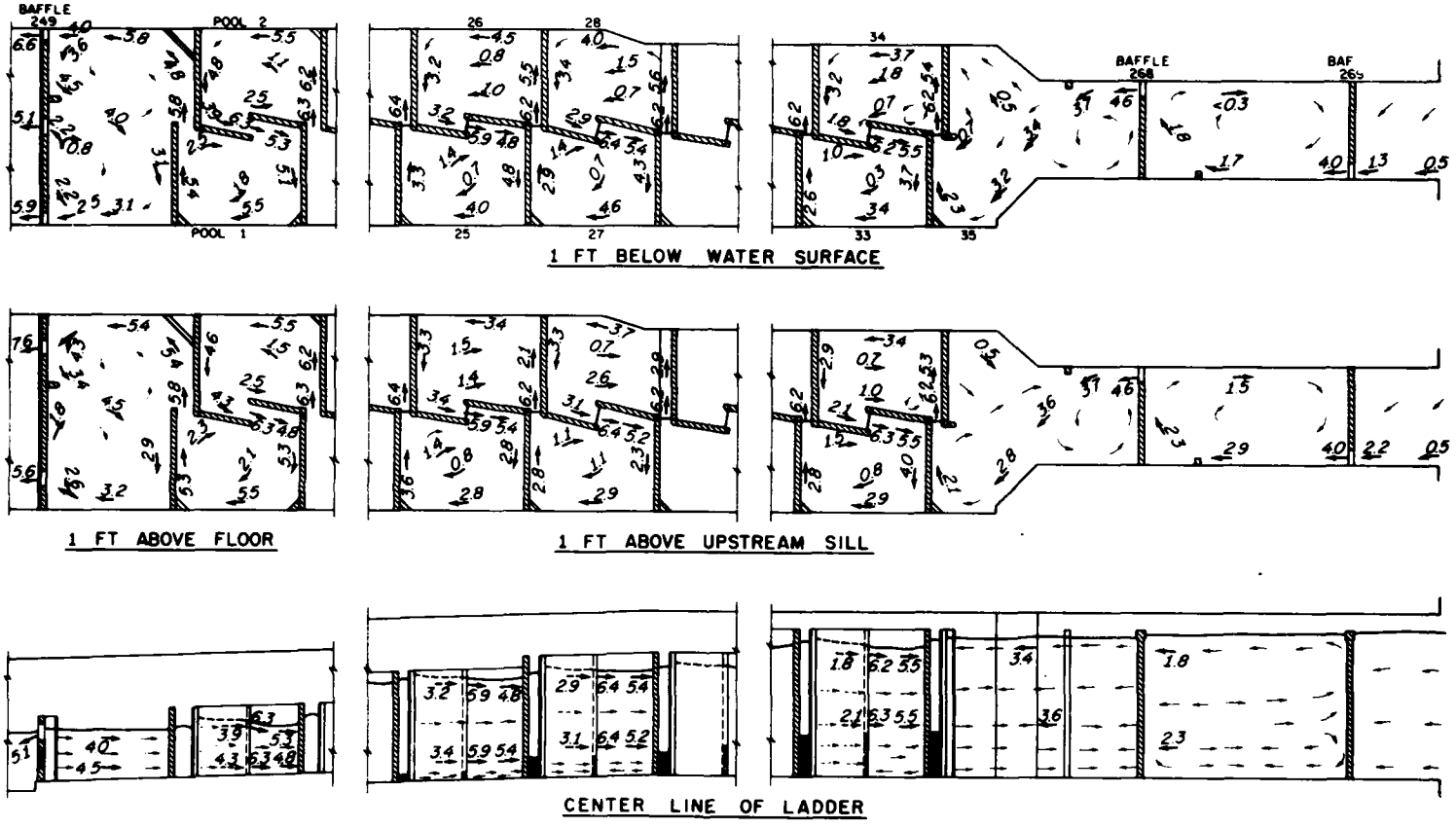
NO	WIDTH "S" IN FT	SILL ELEVATION	WALL LENGTH "L" IN FT	SKEW ANGLE
1	2.08			
2	2.00		6.68	79° 17.2
3	1.92			
4	1.83		6.89	80° 9.0
5	1.79			
6	1.71		7.06	80° 49.1
7	1.67			
8	1.62		7.20	81° 17.0
9	1.54			
10	1.50		7.36	81° 55.9
11	1.46			
12	1.42		7.46	82° 20.9
13	1.38			
14	1.33		7.56	82° 45.6
15	1.29			
16	1.25		7.66	82° 59.7
17	1.25			
18	1.25		7.71	83° 11.7
19	1.25	248.3		
20	1.25	248.7	7.71	83° 11.7
21	1.25	249.1		
22	1.25	249.5	7.71	83° 11.7
23	1.25	249.9		
24	1.25	250.2	7.71	83° 11.7
25	1.25	250.6		
26	1.25	251.0	7.71	83° 11.7
27	1.25	251.4		
28	1.25	251.8	7.67	80° 8.7
29	1.25	252.2		
30	1.25	252.6	7.71	80° 11.7
31	1.25	253.0		
32	1.25	253.4	7.71	80° 11.7
33	1.25	253.8		
34	1.25	254.2	7.71	80° 11.7
35	1.25	254.6		

REGULATING SECTION

SLOT PLAN E

NORTH SHORE FISH LADDER

PLATE 12



NOTES

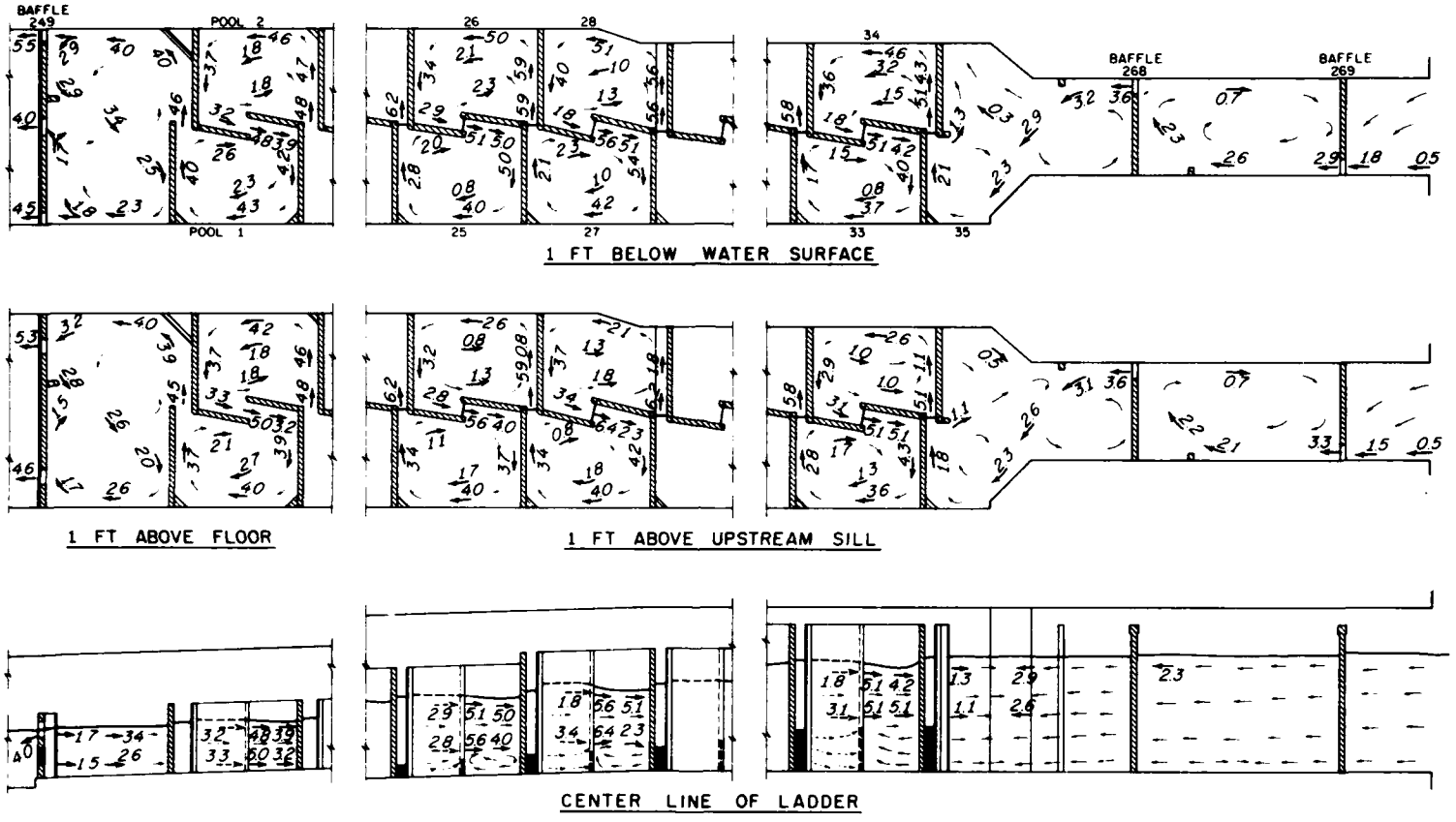
1 VELOCITIES MEASURED WITH MIDGET CURRENT METER, METER AXIS HORIZONTAL
2 LADDER DISCHARGE 82.2 CFS
3 POOL AND BAFFLE DETAILS SHOWN ON PLATE 12.

FOREBAY ELEV 268
DISCHARGE 70.1 CFS

VELOCITIES
SLOT PLAN E
NORTH SHORE FISH LADDER

PLATE 13A

PLATE 13B



NOTES

1 VELOCITIES MEASURED WITH MIDGET CURRENT METER, METER AXIS HORIZONTAL

2 LADDER DISCHARGE 82 2 CFS

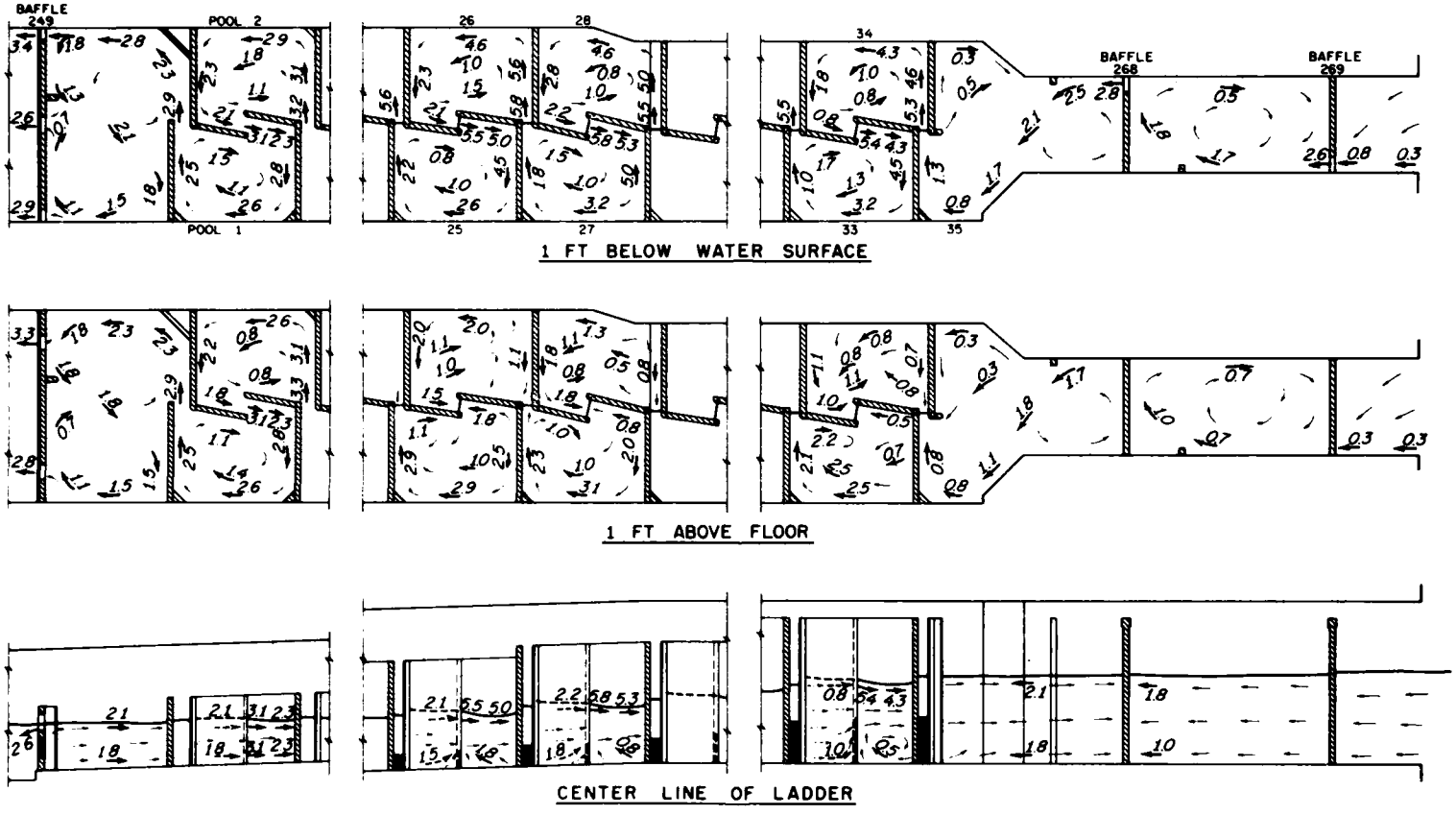
3 POOL AND BAFFLE DETAILS SHOWN ON PLATE 12.

FOREBAY ELEV 265
DISCHARGE 56.8 CFS

VELOCITIES

SLOT PLAN E

NORTH SHORE FISH LADDER



NOTES

1 VELOCITIES MEASURED WITH MIDGET CURRENT METER, METER AXIS HORIZONTAL

2 LADDER DISCHARGE 82 2 CFS

3 POOL AND BAFFLE DETAILS SHOWN ON PLATE 12.

FOREBAY ELEV 262
DISCHARGE 27.2 CFS

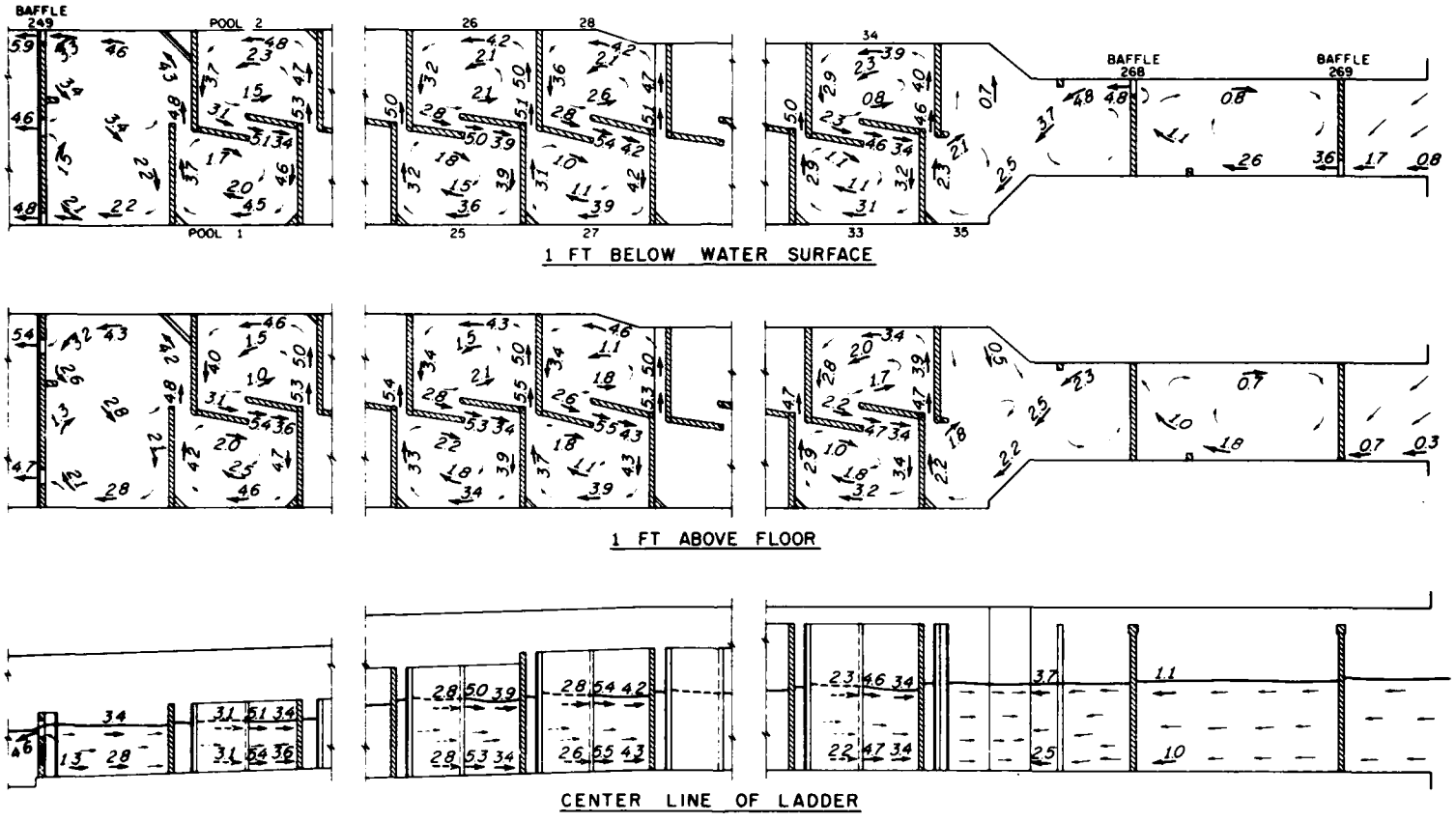
VELOCITIES

SLOT PLAN E

NORTH SHORE FISH LADDER
REMOVABLE SILLS IN

PLATE 14A

PLATE 14B



NOTES

1 VELOCITIES MEASURED WITH MIDGET CURRENT METER, METER AXIS HORIZONTAL
2 LADDER DISCHARGE 82 2 CFS
3 POOL AND BAFFLE DETAILS SHOWN ON PLATE 12.

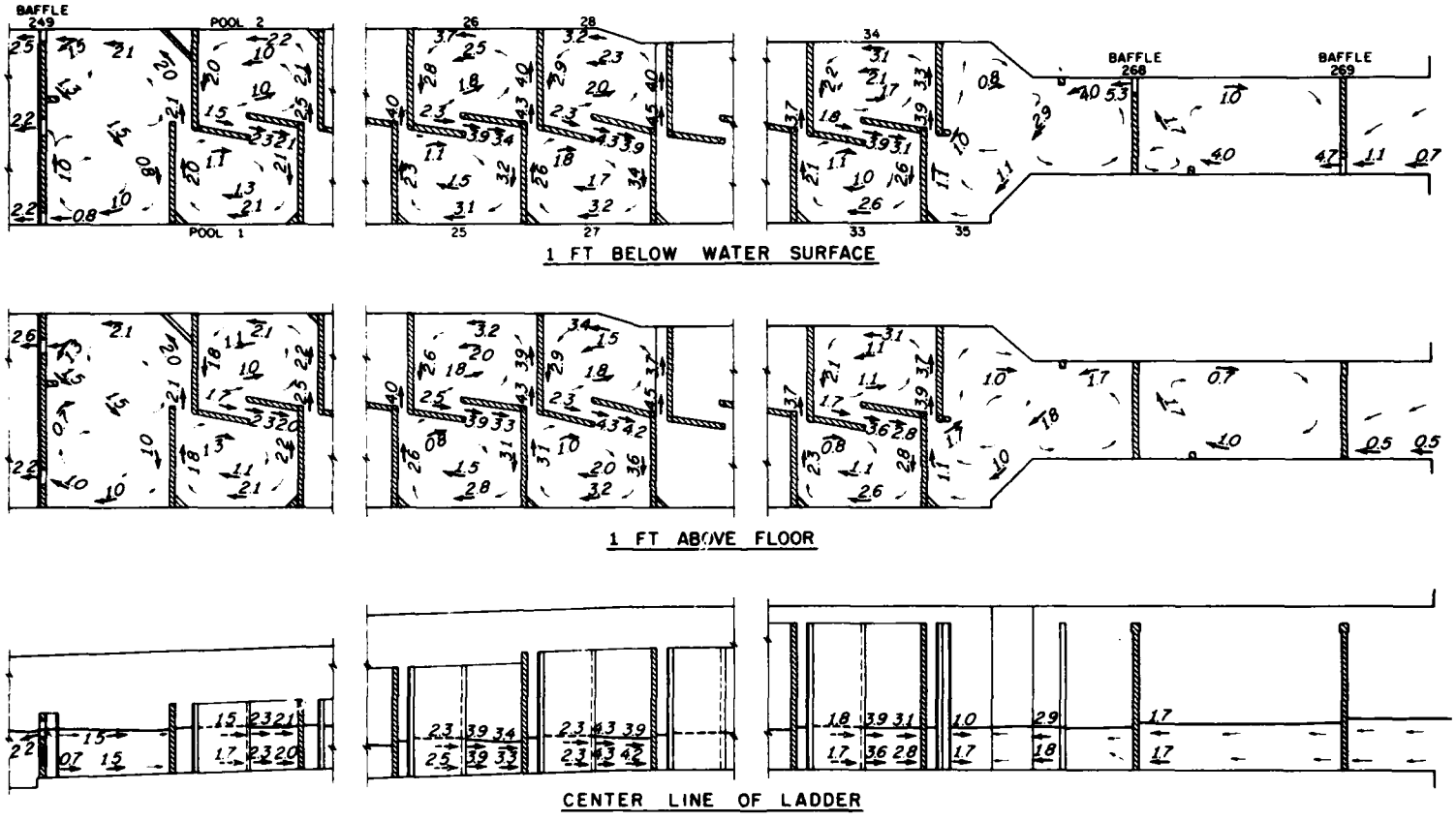
FOREBAY ELEV 262
DISCHARGE 512 CFS

VELOCITIES

SLOT PLAN E

NORTH SHORE FISH LADDER

REMOVABLE SILLS OUT



NOTES

1 VELOCITIES MEASURED WITH MIDGET CURRENT METER, METER AXIS HORIZONTAL

2 LADDER DISCHARGE 82.2 CFS

3 POOL AND BAFFLE DETAILS SHOWN ON **PLATE 12.**

FOREBAY ELEV 257
DISCHARGE 20.0 CFS

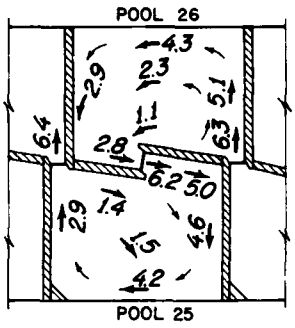
VELOCITIES

SLOT PLAN E

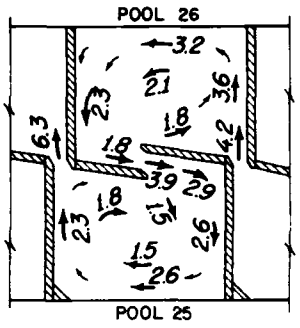
NORTH SHORE FISH LADDER

PLATE 15

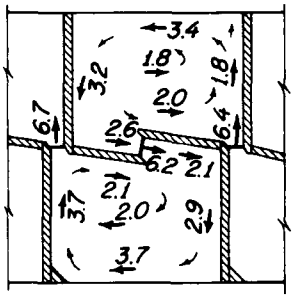
FOREBAY ELEV 268



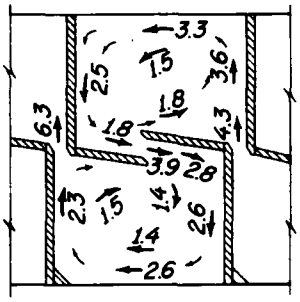
FOREBAY ELEV 257



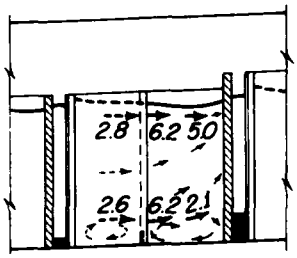
1 FT BELOW WATER SURFACE

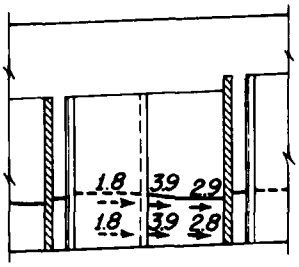


1 FT ABOVE
UPSTREAM SILL



1 FT ABOVE
FLOOR





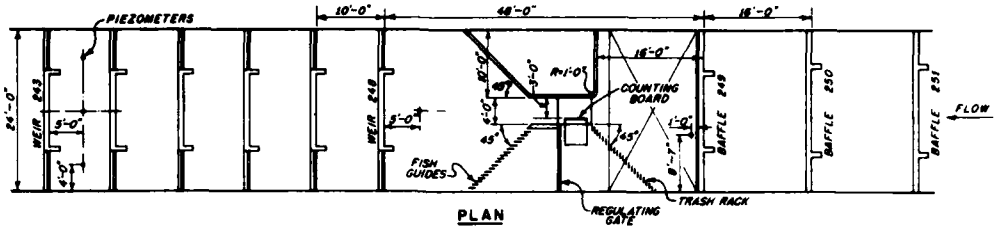
CENTER LINE OF LADDER

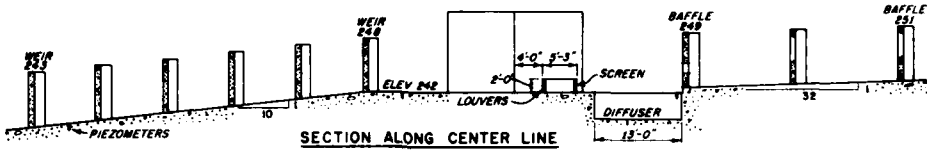
NOTES

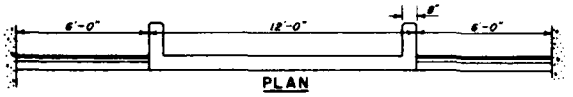
1. VELOCITIES MEASURED WITH MIDGET CURRENT METER, METER AXIS HORIZONTAL.
2. POOL AND BAFFLE DETAILS SHOWN ON PLATE 12.

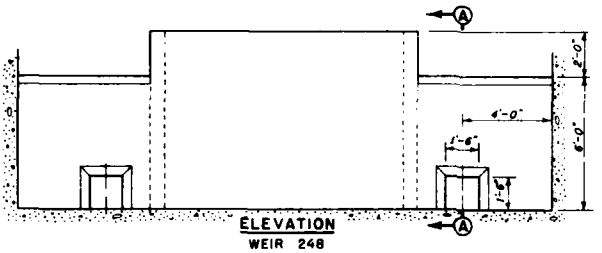
VELOCITIES
SLOT PLAN E
6-IN. SLOT BEVEL
NORTH SHORE FISH LADDER

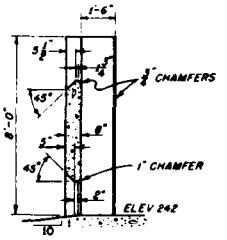
PLATE 16

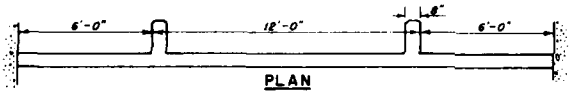


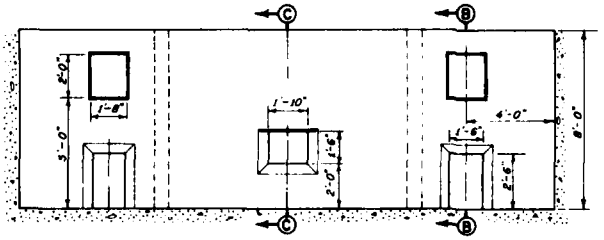


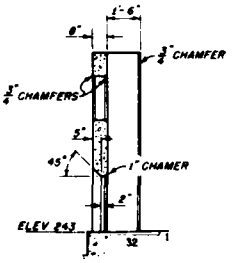


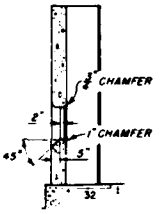


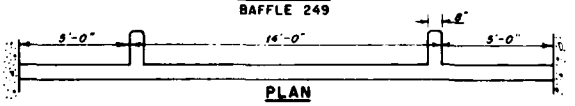


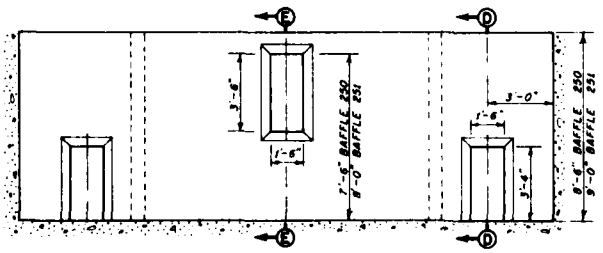


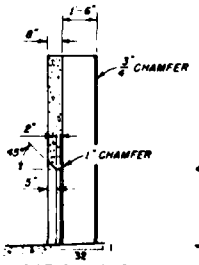


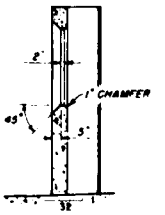










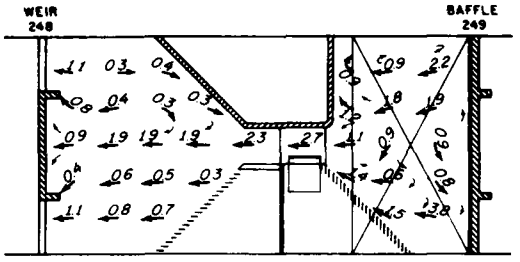


VERTICAL COUNTING STATION
NORTH FISH LADDER

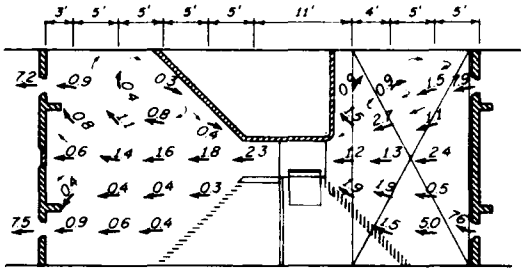
EXISTING CONTROL SECTION

PLATE 17

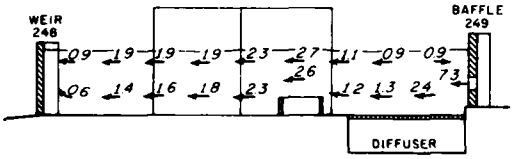
MINIMUM DROP AT COUNTING BOARD



TOP OF DOWNSTREAM WEIR



CENTER LINE OF UPSTREAM ORIFICE

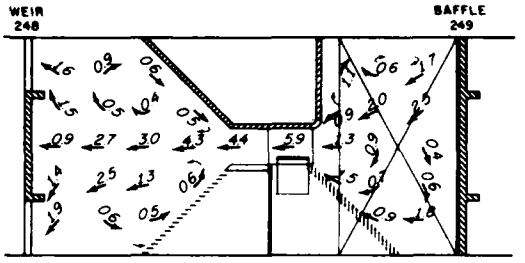


CENTER LINE OF LADDER

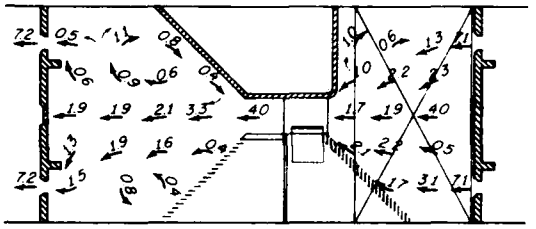
OPERATING CONDITIONS

HEAD ON WEIR 248 12 6 INCHES
FOREBAY ELEVATION 265
CONTROL SECTION DISCHARGE 860 CFS
DIFFUSER DISCHARGE 0 0 CFS
LADDER DISCHARGE 860 CFS

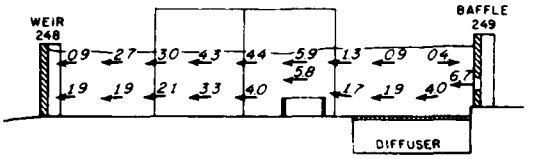
3-IN. DROP AT COUNTING BOARD



TOP OF DOWNSTREAM WEIR



CENTER LINE OF UPSTREAM ORIFICE



CENTER LINE OF LADDER

OPERATING CONDITIONS

HEAD ON WEIR 248 13 0 INCHES
FOREBAY ELEVATION 265
CONTROL SECTION DISCHARGE 860 CFS
DIFFUSER DISCHARGE 0 0 CFS
LADDER DISCHARGE 860 CFS

NOTES

1 VELOCITIES MEASURED WITH MIDGET CURRENT METER, METER AXIS HORIZONTAL

2 HEAD ON WEIRS DETERMINED FROM WATER-SURFACE 5-FT UPSTREAM FROM WEIR FACE.

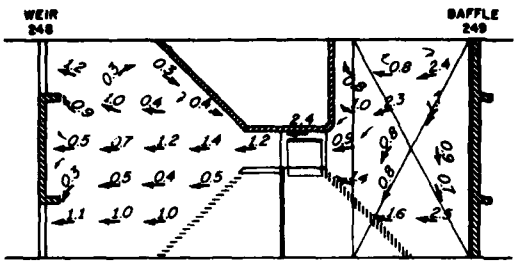
HEAD ON OVERFLOW WEIRS 12.9 INCHES

VELOCITIES AT VERTICAL COUNTING STATION

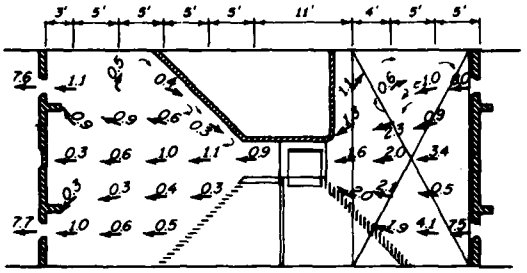
NORTH SHORE FISH LADDER WITH PLAN 10 WEIRS
EXISTING CONTROL SECTION
COUNTING BOARD OPEN 36 INCHES

PLATE 18

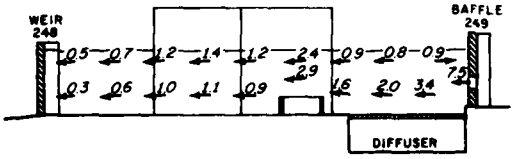
MINIMUM DROP AT COUNTING BOARD



TOP OF DOWNSTREAM WEIR



CENTER LINE OF UPSTREAM ORIFICE

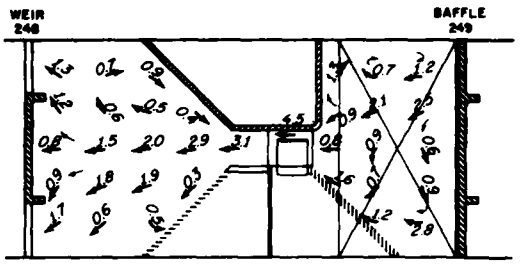


CENTER LINE OF LADDER

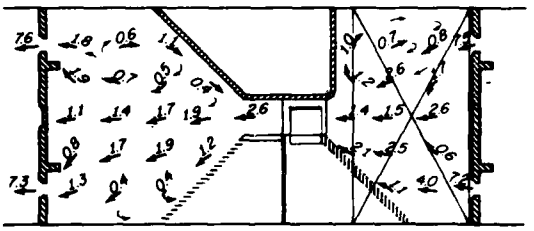
OPERATING CONDITIONS

HEAD ON WEIR 248 12 6 INCHES
FOREBAY ELEVATION 265
CONTROL SECTION DISCHARGE 86 0 CFS
DIFFUSER DISCHARGE 0 0 CFS
LADDER DISCHARGE 86 0 CFS

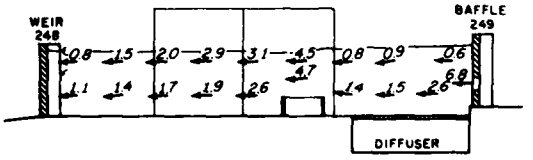
3-IN. DROP AT COUNTING BOARD



TOP OF DOWNSTREAM WEIR



CENTER LINE OF UPSTREAM ORIFICE



CENTER LINE OF LADDER

OPERATING CONDITIONS

HEAD ON WEIR 248 12 7 INCHES
FOREBAY ELEVATION 265
CONTROL SECTION DISCHARGE 86 0 CFS
DIFFUSER DISCHARGE 0 0 CFS
LADDER DISCHARGE 86 0 CFS

NOTES

1. VELOCITIES MEASURED WITH MIDGET CURRENT METER, METER AXIS HORIZONTAL.
2. HEAD ON WEIRS DETERMINED FROM WATER-SURFACE 5-FT UPSTREAM FROM WEIR FACE.

HEAD ON OVERFLOW WEIRS 12 9 INCHES

VELOCITIES AT VERTICAL COUNTING STATION

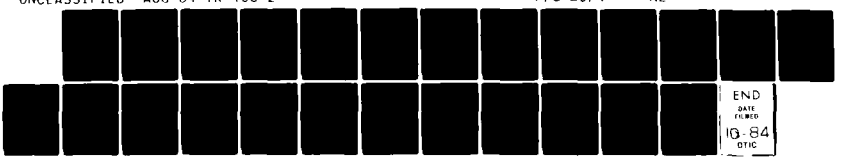
NORTH SHORE FISH LADDER WITH PLAN 10 WEIRS
EXISTING CONTROL SECTION
COUNTING BOARD OPEN 9 INCHES

PLATE 19

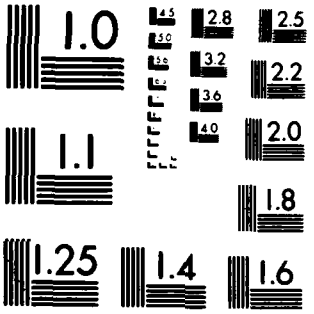
AD-A145 949 MODIFICATION OF FISH LADDERS AT JOHN DAY DAM COLUMBIA RIVER OREGON AND WA..(U) ARMY ENGINEER DIV NORTH PACIFIC BONNEVILLE OR DIV HYDRAULIC L.. P M SMITH

2/7

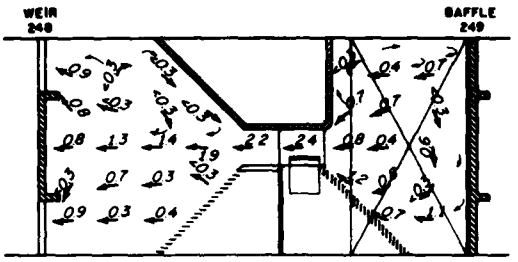
UNCLASSIFIED AUG 84 TR-103-2 F/G 20/4 NL



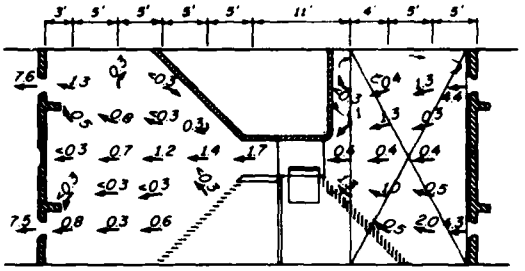
END
DATE FILMED
10-84
DTIC



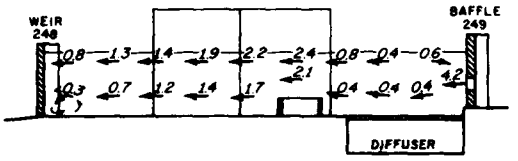
MINIMUM DROP AT COUNTING BOARD



TOP OF DOWNSTREAM WEIR



CENTER LINE OF UPSTREAM ORIFICE

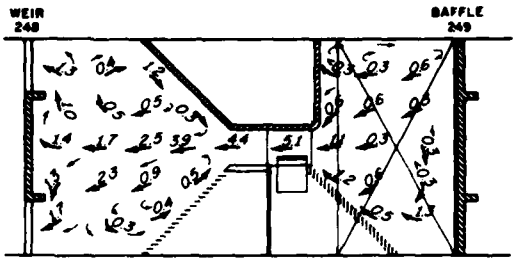


CENTER LINE OF LADDER

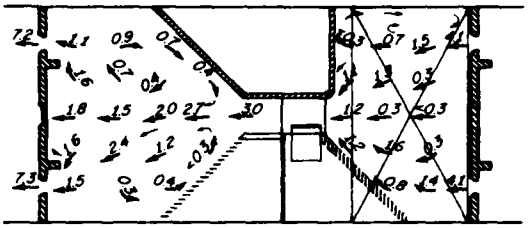
OPERATING CONDITIONS

HEAD ON WEIR 248 11.6 INCHES
FOREBAY ELEVATION 257
CONTROL SECTION DISCHARGE 450 CFS
DIFFUSER DISCHARGE 37.2 CFS
LADDER DISCHARGE 82.2 CFS

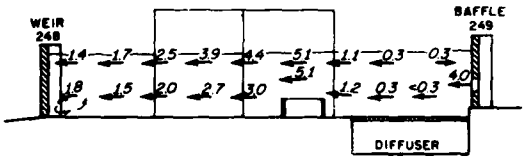
3-IN. DROP AT COUNTING BOARD



TOP OF DOWNSTREAM WEIR



CENTER LINE OF UPSTREAM ORIFICE



CENTER LINE OF LADDER

OPERATING CONDITIONS

HEAD ON WEIR 248 11.6 INCHES
FOREBAY ELEVATION 257
CONTROL SECTION DISCHARGE 450 CFS
DIFFUSER DISCHARGE 37.2 CFS
LADDER DISCHARGE 82.2 CFS

HEAD ON OVERFLOW WEIRS 12.0 INCHES

NOTES

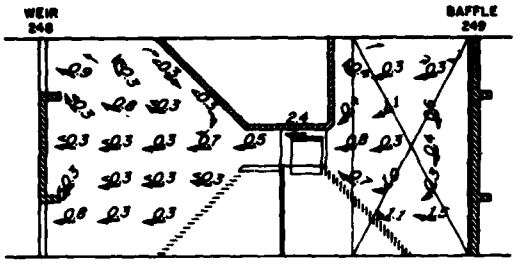
1. VELOCITIES MEASURED WITH MIDGET CURRENT METER, METER AXIS HORIZONTAL.
2. HEAD ON WEIRS DETERMINED FROM WATER-SURFACE 5-FT UPSTREAM FROM WEIR FACE.

VELOCITIES AT VERTICAL COUNTING STATION

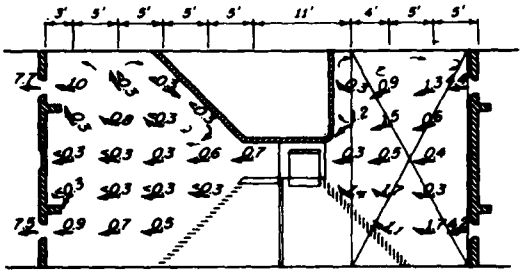
NORTH SHORE FISH LADDER WITH PLAN 10 WEIRS
EXISTING CONTROL SECTION
COUNTING BOARD OPEN 36 INCHES

PLATE 20

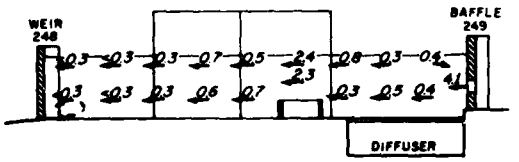
MINIMUM DROP AT COUNTING BOARD



TOP OF DOWNSTREAM WEIR



CENTER LINE OF UPSTREAM ORIFICE

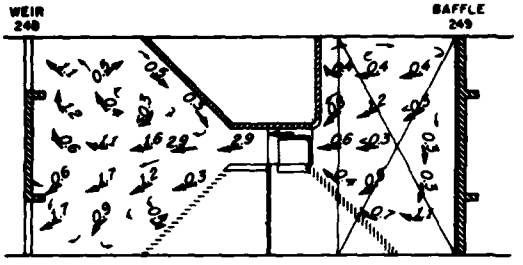


CENTER LINE OF LADDER

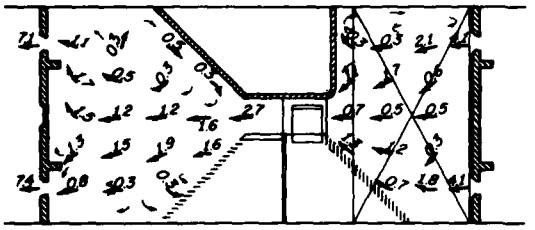
OPERATING CONDITIONS

HEAD ON WEIR 248 11.6 INCHES
FOREBAY ELEVATION 257
CONTROL SECTION DISCHARGE 450 CFS
DIFFUSER DISCHARGE 372 CFS
LADDER DISCHARGE 82.2 CFS

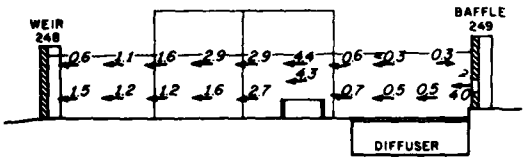
3-IN. DROP AT COUNTING BOARD



TOP OF DOWNSTREAM WEIR



CENTER LINE OF UPSTREAM ORIFICE



CENTER LINE OF LADDER

OPERATING CONDITIONS

HEAD ON WEIR 248 11.6 INCHES
FOREBAY ELEVATION 257
CONTROL SECTION DISCHARGE 450 CFS
DIFFUSER DISCHARGE 372 CFS
LADDER DISCHARGE 82.2 CFS

HEAD ON OVERFLOW WEIRS 12.0 INCHES

NOTES

1 VELOCITIES MEASURED WITH MIDGET CURRENT METER, METER AXIS HORIZONTAL.

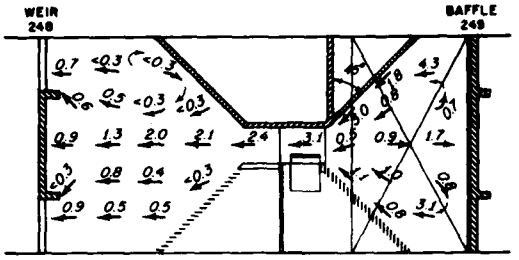
2 HEAD ON WEIRS DETERMINED FROM WATER-SURFACE 5-FT UPSTREAM FROM WEIR FACE.

VELOCITIES AT VERTICAL COUNTING STATION

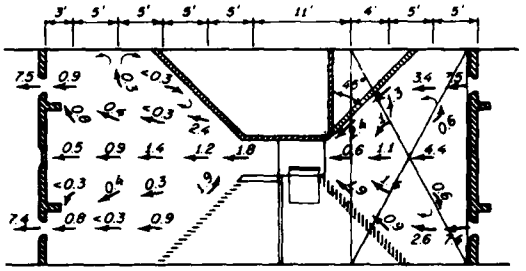
NORTH SHORE FISH LADDER WITH PLAN 10 WEIRS
EXISTING CONTROL SECTION
COUNTING BOARD OPEN 9 INCHES

PLATE 21

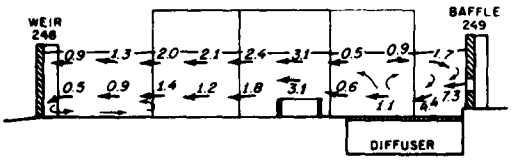
MINIMUM DROP AT COUNTING BOARD



TOP OF DOWNSTREAM WEIR



CENTER LINE OF UPSTREAM ORIFICE

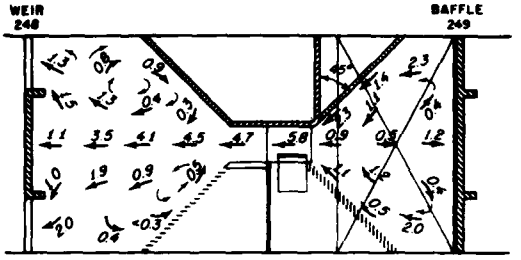


CENTER LINE OF LADDER

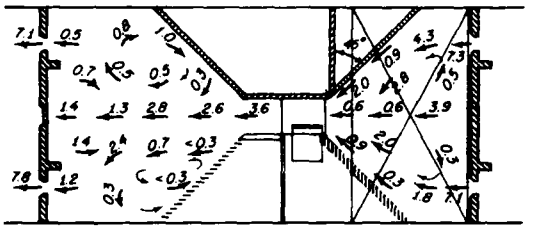
OPERATING CONDITIONS

HEAD ON WEIR 248 12.6 INCHES
FOREBAY ELEVATION 265
CONTROL SECTION DISCHARGE 86.0 CFS
DIFFUSER DISCHARGE 0.0 CFS
LADDER DISCHARGE 86.0 CFS

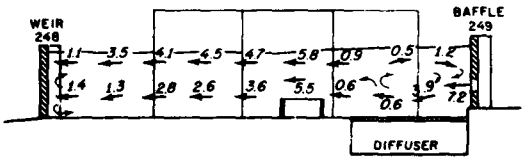
3-IN. DROP AT COUNTING BOARD



TOP OF DOWNSTREAM WEIR



CENTER LINE OF UPSTREAM ORIFICE



CENTER LINE OF LADDER

OPERATING CONDITIONS

HEAD ON WEIR 248 13.0 INCHES
FOREBAY ELEVATION 265
CONTROL SECTION DISCHARGE 86.0 CFS
DIFFUSER DISCHARGE 0.0 CFS
LADDER DISCHARGE 86.0 CFS

REVISED UPSTREAM POOL

HEAD ON OVERFLOW WEIRS 12.9 INCHES

NOTES

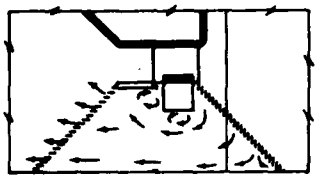
1. VELOCITIES MEASURED WITH MIDGET CURRENT METER, METER AXIS HORIZONTAL.
2. HEAD ON WEIRS DETERMINED FROM WATER-SURFACE 5-FT UPSTREAM FROM WEIR FACE.

VELOCITIES AT VERTICAL COUNTING STATION

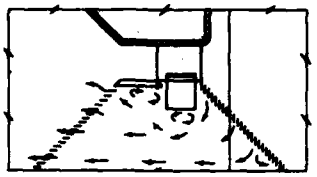
NORTH SHORE FISH LADDER WITH PLAN 10 WEIRS
EXISTING CONTROL SECTION
COUNTING BOARD OPEN 36 INCHES

PLATE 22

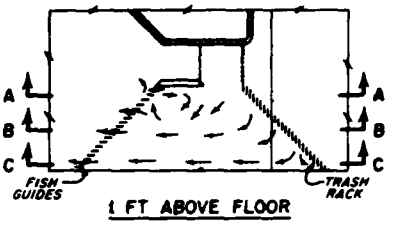
MINIMUM DROP AT COUNTING BOARD



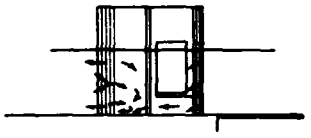
1 FT BELOW SURFACE



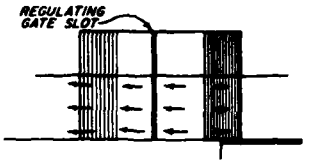
MID-DEPTH



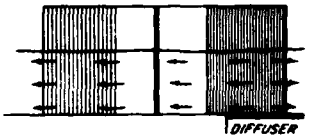
1 FT ABOVE FLOOR



SECTION A-A



SECTION B-B



SECTION C-C

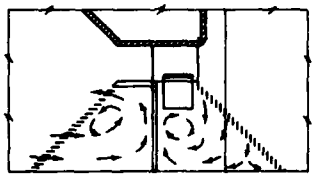
OPERATING CONDITIONS

HEAD ON OVERFLOW WEIRS 12.9 INCHES
HEAD ON WEIR 248 12.6 INCHES
FOREBAY ELEVATION 265
CONTROL SECTION DISCHARGE 86.0 CFS
DIFFUSER DISCHARGE 0.0 CFS
LADDER DISCHARGE 86.0 CFS
COUNTING BOARD OPEN 36 INCHES

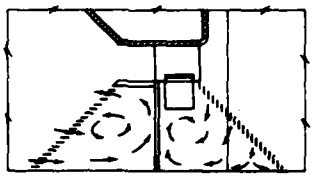
NOTES

1. HEAD ON WEIRS DETERMINED FROM WATER-SURFACE 5-FT UPSTREAM FROM WEIR FACE.
2. COUNTING STATION DETAILS SHOWN ON PLATE 17

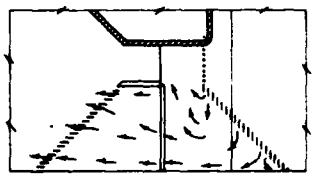
2-IN. DROP AT COUNTING BOARD



1 FT BELOW SURFACE



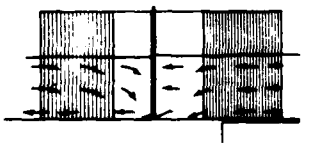
MID-DEPTH



1 FT ABOVE FLOOR

SECTION A-A

SECTION B-B



SECTION C-C

OPERATING CONDITIONS

HEAD ON OVERFLOW WEIRS 12.9 INCHES
HEAD ON WEIR 248 12.5 INCHES
FOREBAY ELEVATION 265
CONTROL SECTION DISCHARGE 86.0 CFS
DIFFUSER DISCHARGE 0.0 CFS
LADDER DISCHARGE 86.0 CFS
COUNTING BOARD OPEN 36 INCHES

90-DEGREE TRASH RACK VANES

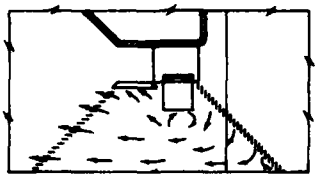
FLOW DIRECTIONS AT FISH GUIDES

VERTICAL COUNTING STATION

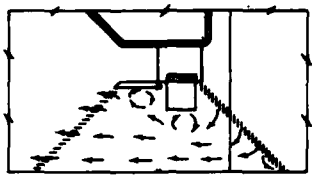
EXISTING CONTROL SECTION
NORTH SHORE FISH LADDER

PLATE 23

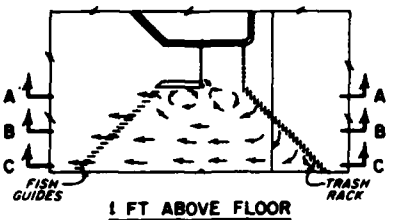
MINIMUM DROP AT COUNTING BOARD



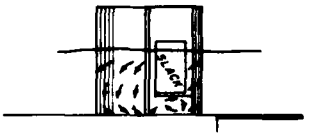
1 FT BELOW SURFACE



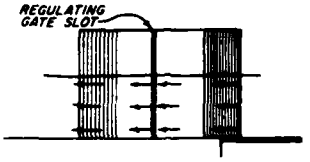
MID-DEPTH



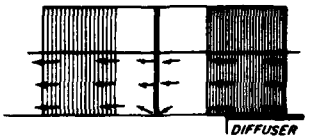
1 FT ABOVE FLOOR



SECTION A-A



SECTION B-B



SECTION C-C

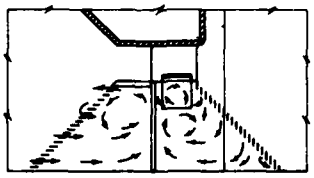
OPERATING CONDITIONS

HEAD ON OVERFLOW WEIRS 12.0 INCHES
HEAD ON WEIR 248 11.6 INCHES
FOREBAY ELEVATION 257
CONTROL SECTION DISCHARGE 45.0 CFS
DIFFUSER DISCHARGE 37.2 CFS
LADDER DISCHARGE 82.2 CFS
COUNTING BOARD OPEN 36 INCHES

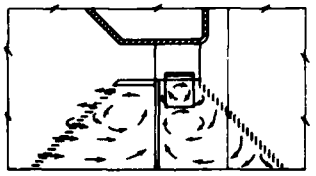
NOTES

1. HEAD ON WEIRS DETERMINED FROM WATER-SURFACE 5-FT UPSTREAM FROM WEIR FACE
2. COUNTING STATION DETAILS SHOWN ON PLATE 17.

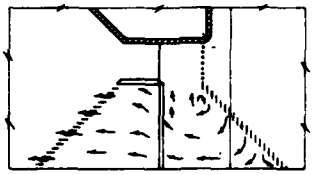
2-IN. DROP AT COUNTING BOARD



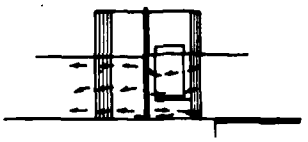
1 FT BELOW SURFACE



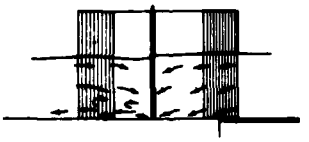
MID-DEPTH



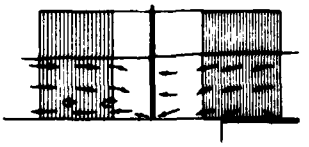
1 FT ABOVE FLOOR



SECTION A-A



SECTION B-B



SECTION C-C

OPERATING CONDITIONS

HEAD ON OVERFLOW WEIRS 12.0 INCHES
HEAD ON WEIR 248 11.6 INCHES
FOREBAY ELEVATION 257
CONTROL SECTION DISCHARGE 45.0 CFS
DIFFUSER DISCHARGE 37.2 CFS
LADDER DISCHARGE 82.2 CFS
COUNTING BOARD OPEN 36 INCHES

90-DEGREE TRASH RACK VANES

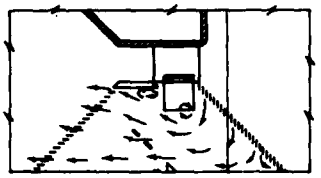
FLOW DIRECTIONS AT FISH GUIDES

VERTICAL COUNTING STATION

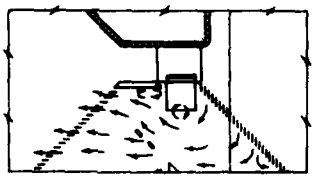
EXISTING CONTROL SECTION
NORTH SHORE FISH LADDER

PLATE 24

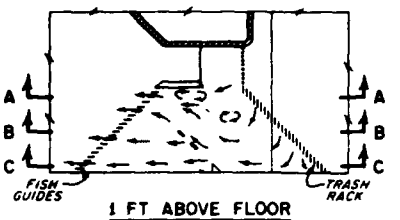
MINIMUM DROP AT COUNTING BOARD



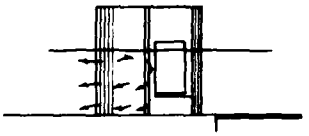
1 FT BELOW SURFACE



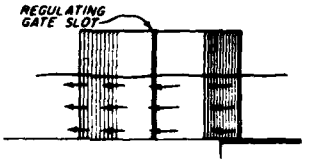
MID-DEPTH



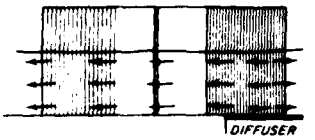
1 FT ABOVE FLOOR



SECTION A-A



SECTION B-B



SECTION C-C

OPERATING CONDITIONS

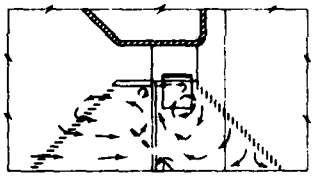
HEAD ON OVERFLOW WEIRS 12 9 INCHES
HEAD ON WEIR 248 12 6 INCHES
FOREBAY ELEVATION 265
CONTROL SECTION DISCHARGE 86 0 CFS
DIFFUSER DISCHARGE 0 0 CFS
LADDER DISCHARGE 86 0 CFS
COUNTING BOARD OPEN 36 INCHES

NOTES

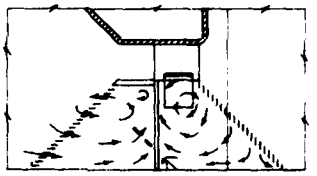
1 HEAD ON WEIRS DETERMINED FROM WATER-SURFACE 5-FT UPSTREAM FROM WEIR FACE

2 COUNTING STATION DETAILS SHOWN ON PLATE 17

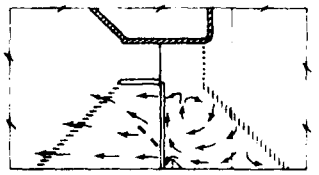
2-IN. DROP AT COUNTING BOARD



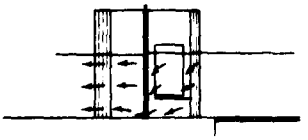
1 FT BELOW SURFACE



MID-DEPTH

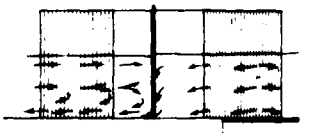


1 FT ABOVE FLOOR



SECTION A-A

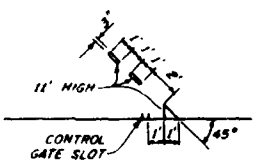
SECTION B-B



SECTION C-C

OPERATING CONDITIONS

HEAD ON OVERFLOW WEIRS 12 9 INCHES
HEAD ON WEIR 248 12 5 INCHES
FOREBAY ELEVATION 265
CONTROL SECTION DISCHARGE 86 0 CFS
DIFFUSER DISCHARGE 0 0 CFS
LADDER DISCHARGE 86 0 CFS
COUNTING BOARD OPEN 36 INCHES



DEFLECTOR DETAILS

90-DEGREE TRASH RACK VANES
FLOW DEFLECTORS

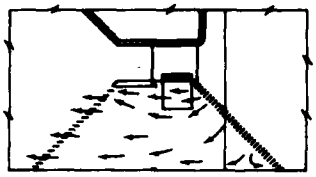
FLOW DIRECTIONS AT FISH GUIDES

VERTICAL COUNTING STATION

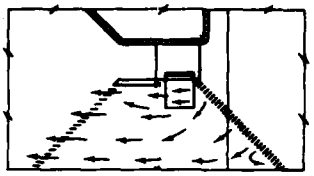
EXISTING CONTROL SECTION
NORTH SHORE FISH LADDER

PLATE 25

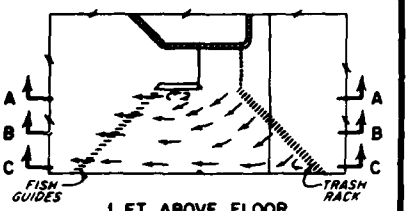
MINIMUM DROP AT COUNTING BOARD



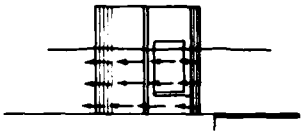
1 FT BELOW SURFACE



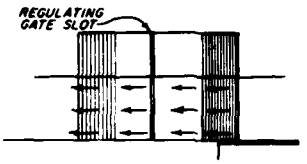
MID-DEPTH



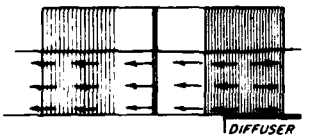
1 FT ABOVE FLOOR



SECTION A-A



SECTION B-B



SECTION C-C

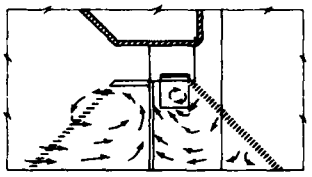
OPERATING CONDITIONS

HEAD ON OVERFLOW WEIRS 12.9 INCHES
HEAD ON WEIR 248 12.6 INCHES
FOREBAY ELEVATION 265
CONTROL SECTION DISCHARGE 86.0 CFS
DIFFUSER DISCHARGE 0.0 CFS
LADDER DISCHARGE 86.0 CFS
COUNTING BOARD OPEN 36 INCHES

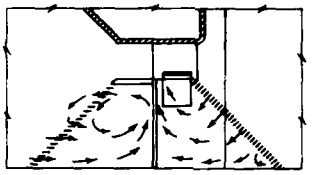
NOTES

1. HEAD ON WEIRS DETERMINED FROM WATER-SURFACE 5-FT UPSTREAM FROM WEIR FACE
2. COUNTING STATION DETAILS SHOWN ON PLATE 17.

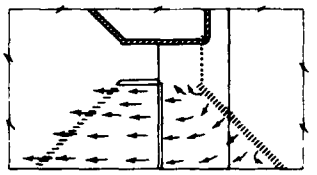
2-IN. DROP AT COUNTING BOARD



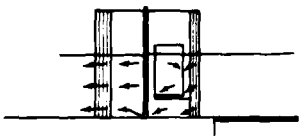
1 FT BELOW SURFACE



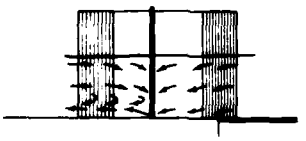
MID-DEPTH



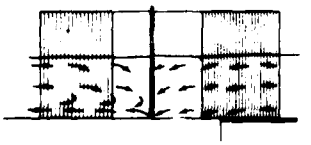
1 FT ABOVE FLOOR



SECTION A-A



SECTION B-B



SECTION C-C

OPERATING CONDITIONS

HEAD ON OVERFLOW WEIRS 12.9 INCHES
HEAD ON WEIR 248 12.5 INCHES
FOREBAY ELEVATION 265
CONTROL SECTION DISCHARGE 86.0 CFS
DIFFUSER DISCHARGE 0.0 CFS
LADDER DISCHARGE 86.0 CFS
COUNTING BOARD OPEN 36 INCHES

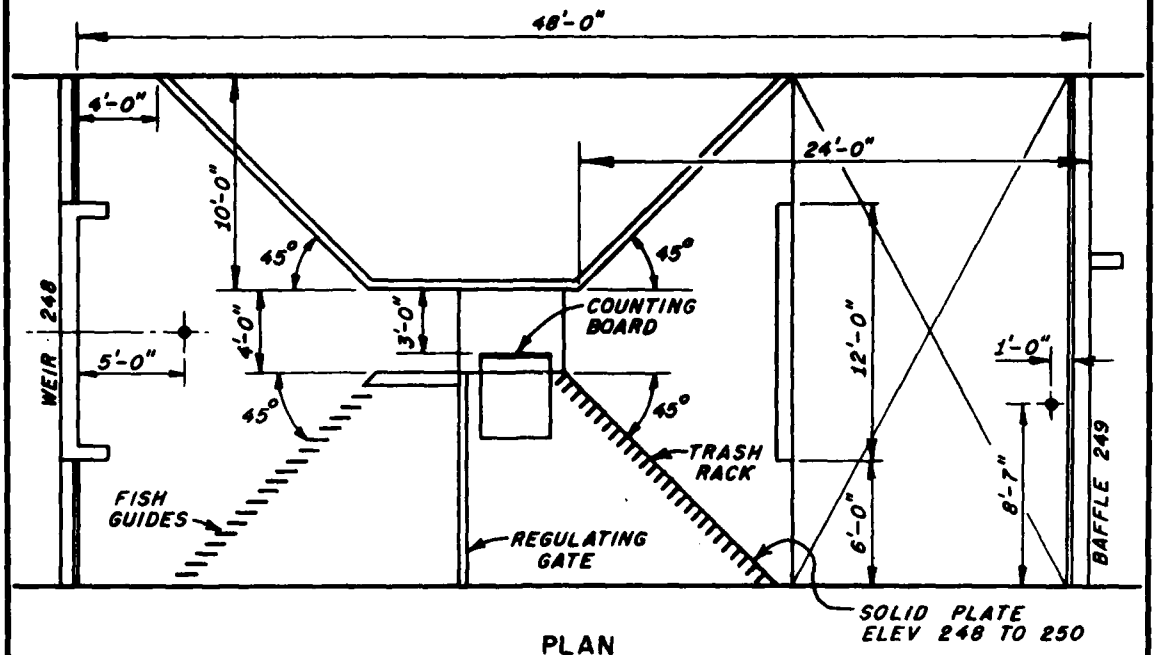
45-DEGREE TRASH RACK VALUES

FLOW DIRECTIONS AT FISH GUIDES

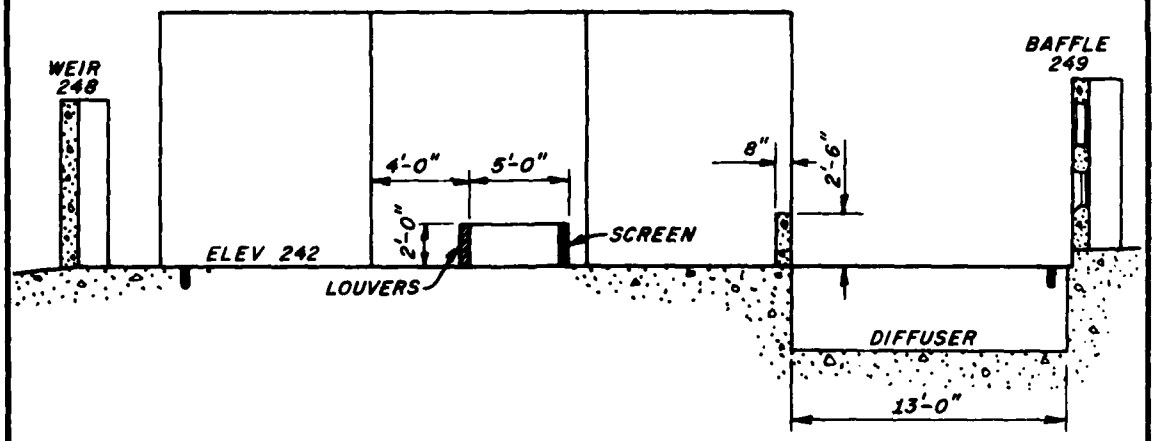
VERTICAL COUNTING STATION

EXISTING CONTROL SECTION
NORTH SHORE FISH LADDER

PLATE 26



PLAN



SECTION ALONG CENTER LINE

NOTE

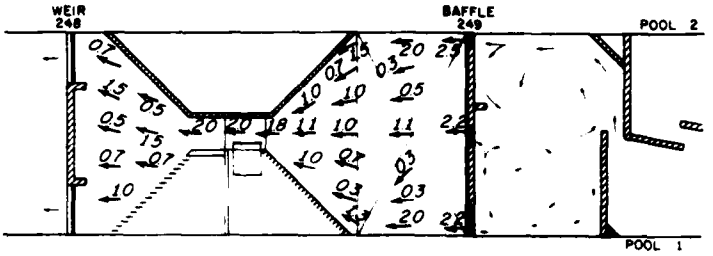
DETAILS OF WEIR 248 SHOWN ON PLATE 17. DETAILS OF BAFFLE 249 SHOWN ON PLATE 12.

VERTICAL COUNTING STATION

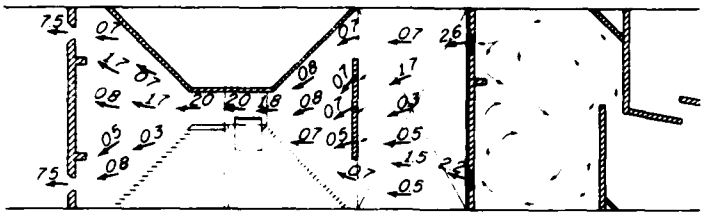
PLAN C

NORTH SHORE FISH LADDER

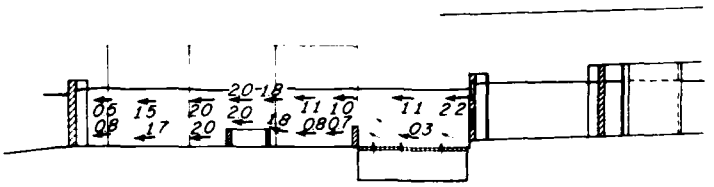
PLATE 27



TOP OF DOWNSTREAM WEIR



CENTER LINE OF UPSTREAM ORIFICE



CENTER LINE OF LADDER

OPERATING CONDITIONS

HEAD ON OVERFLOW WEIRS 12.0 INCHES
HEAD ON WEIR 248 12.0 INCHES
REGULATING SECTION DISCHARGE 200 CFS
DIFFUSER DISCHARGE 62.2 CFS
LADDER DISCHARGE 82.2 CFS

COUNTING BOARD OPEN 36 INCHES
WITH MINIMUM DROP

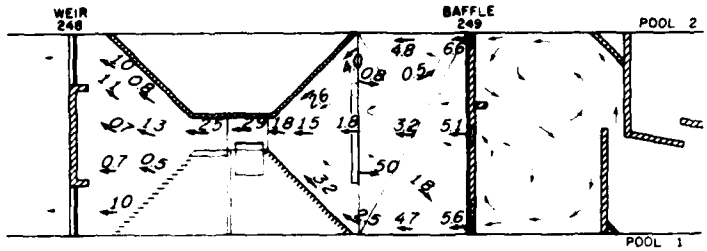
NOTES

1 VELOCITIES MEASURED WITH MIDGET CURRENT METER, METER AXIS HORIZONTAL
2 HEAD ON WEIRS DETERMINED FROM WATER-SURFACE 5-FT UPSTREAM FROM WEIR FACE
3 REGULATING SECTION, SLOT-ORIFICE PLAN E
4 VELOCITIES IN POOL 249 SHOWN ON PLATE 5

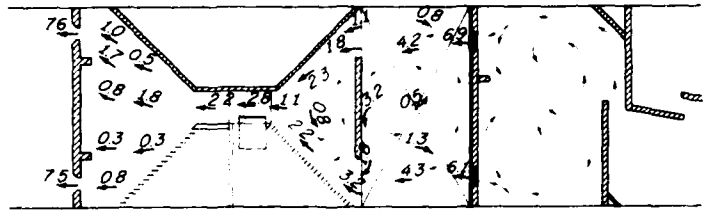
VELOCITIES

PLAN C VERTICAL COUNTING STATION
NORTH SHORE FISH LADDER
FOREBAY ELEV 257

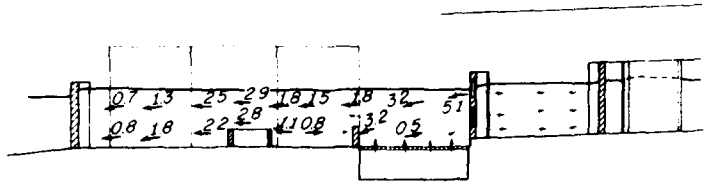
PLATE 28



TOP OF DOWNSTREAM WEIR



CENTER LINE OF UPSTREAM ORIFICE



CENTER LINE OF LADDER

OPERATING CONDITIONS

HEAD ON OVERFLOW WEIRS 12.0 INCHES
HEAD ON WEIR 248 12.0 INCHES
REGULATING SECTION DISCHARGE 70.1 CFS
DIFFUSER DISCHARGE 12.1 CFS
LADDER DISCHARGE 82.2 CFS

COUNTING BOARD OPEN 36 INCHES
WITH MINIMUM DROP

NOTES

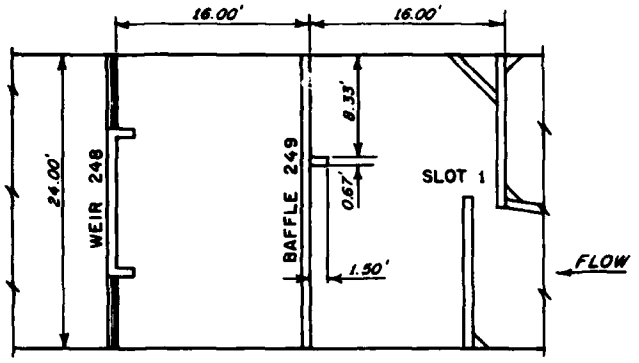
1 VELOCITIES MEASURED WITH MIDGET CURRENT METER, METER AXIS HORIZONTAL
2 HEAD ON WEIRS DETERMINED FROM WATER-SURFACE 5-FT UPSTREAM FROM WEIR FACE
3 REGULATING SECTION, SLOT-ORIFICE PLAN E
4 VELOCITIES IN POOL 249 SHOWN ON PLATE 13A

VELOCITIES

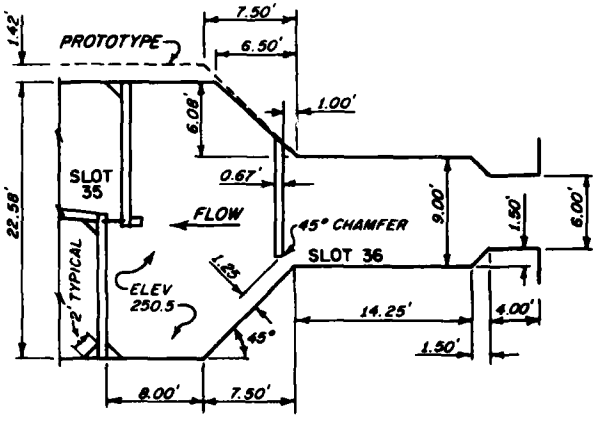
PLAN C VERTICAL COUNTING STATION
NORTH SHORE FISH LADDER
FOREBAY ELEV 266

PLATE 29

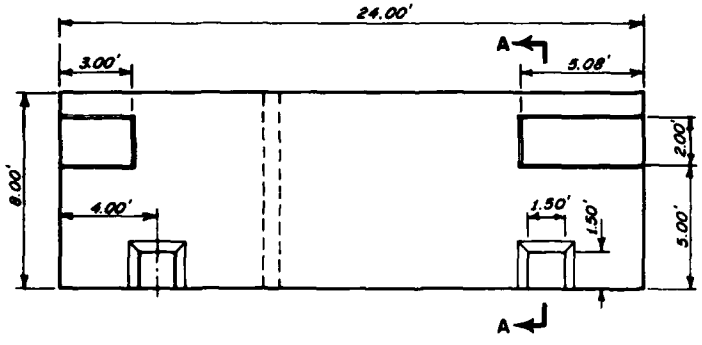
PLATE 30



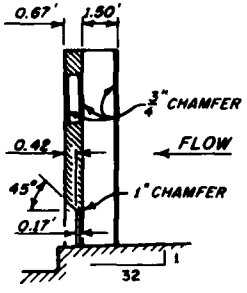
ENTRANCE POOLS



EXIT POOLS



BAFFLE 249



SECTION A-A

NOTE

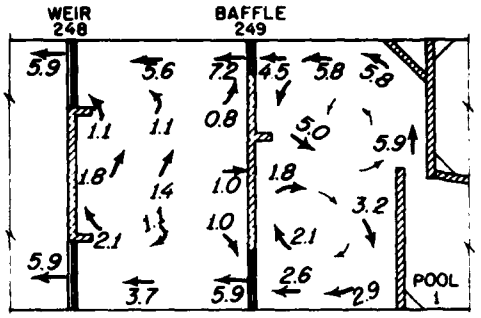
DETAILS OF WEIR 248 AND SLOT 1 SAME AS THOSE FOR NORTH SHORE LADDER SHOWN ON PLATE 12 EXCEPT ORIFICES IN WEIR 248 ARE 18 INCHES HIGH.

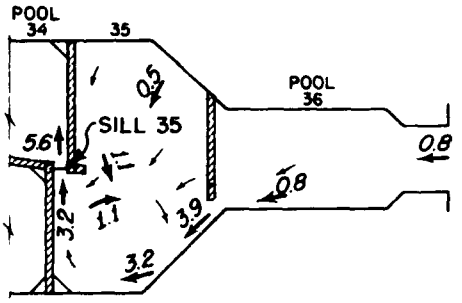
DETAILS

ENTRANCE AND EXIT POOLS

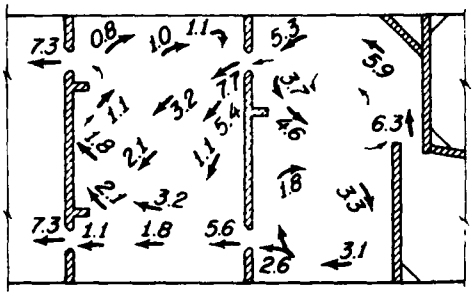
SLOT PLAN E

SOUTH SHORE FISH LADDER

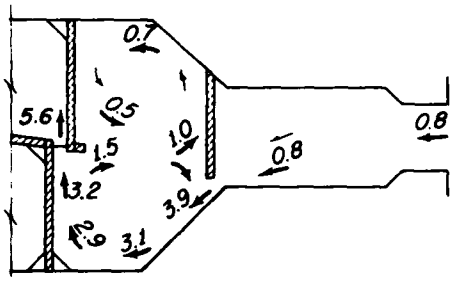




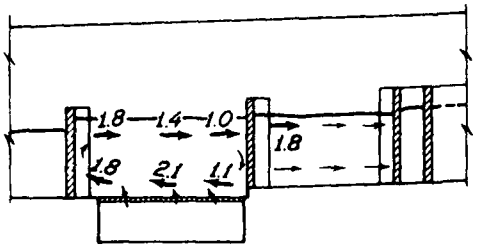
1 FT BELOW WATER SURFACE

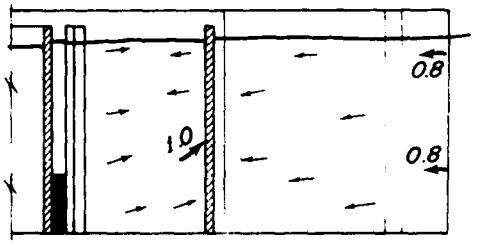


1 FT ABOVE FLOOR



1 FT ABOVE SILL 35





CENTER LINE OF LADDER

OPERATING CONDITIONS

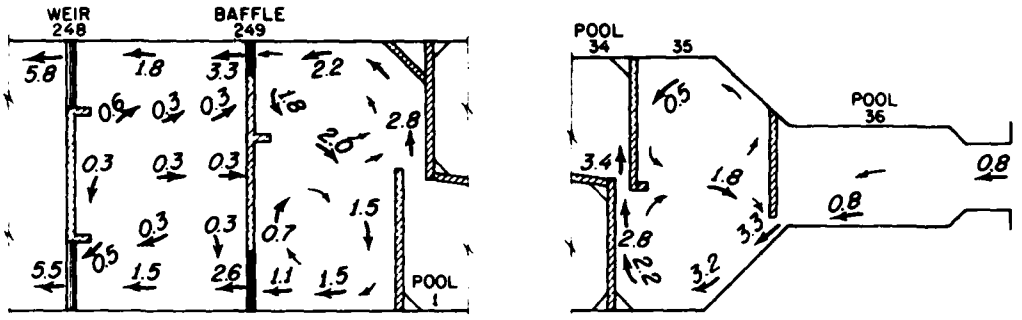
HEAD ON WEIR 248 12.0 INCHES
REGULATING SECTION DISCHARGE 739 CFS
DIFFUSER DISCHARGE 8.3 CFS
LADDER DISCHARGE 82.2 CFS

NOTES

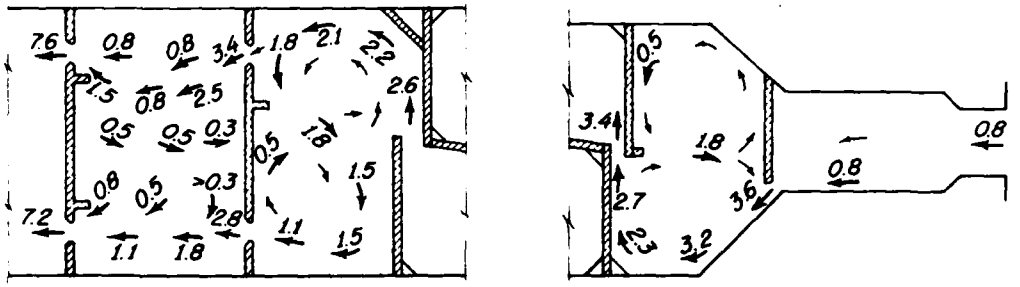
1. VELOCITIES MEASURED WITH MIDGET CURRENT METER, METER AXIS HORIZONTAL.
2. POOL AND BAFFLE DETAILS SHOWN ON PLATES 12 AND 30.

VELOCITIES
ENTRANCE AND EXIT POOLS
SLOT PLAN E
SOUTH SHORE FISH LADDER
FOREBAY ELEV 268

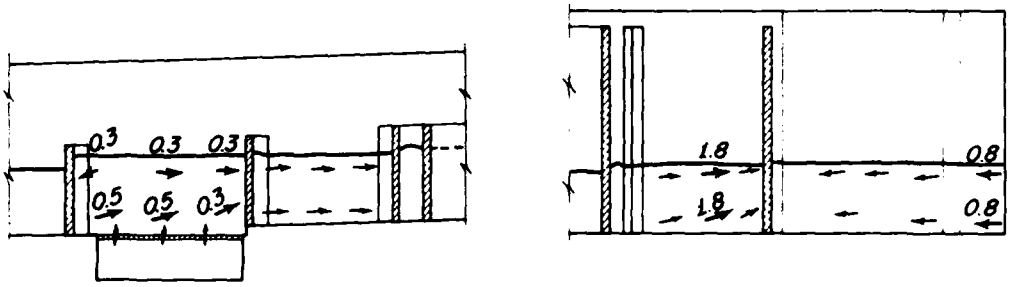
PLATE 31



1 FT BELOW WATER SURFACE



1 FT ABOVE FLOOR



CENTER LINE OF LADDER

OPERATING CONDITIONS

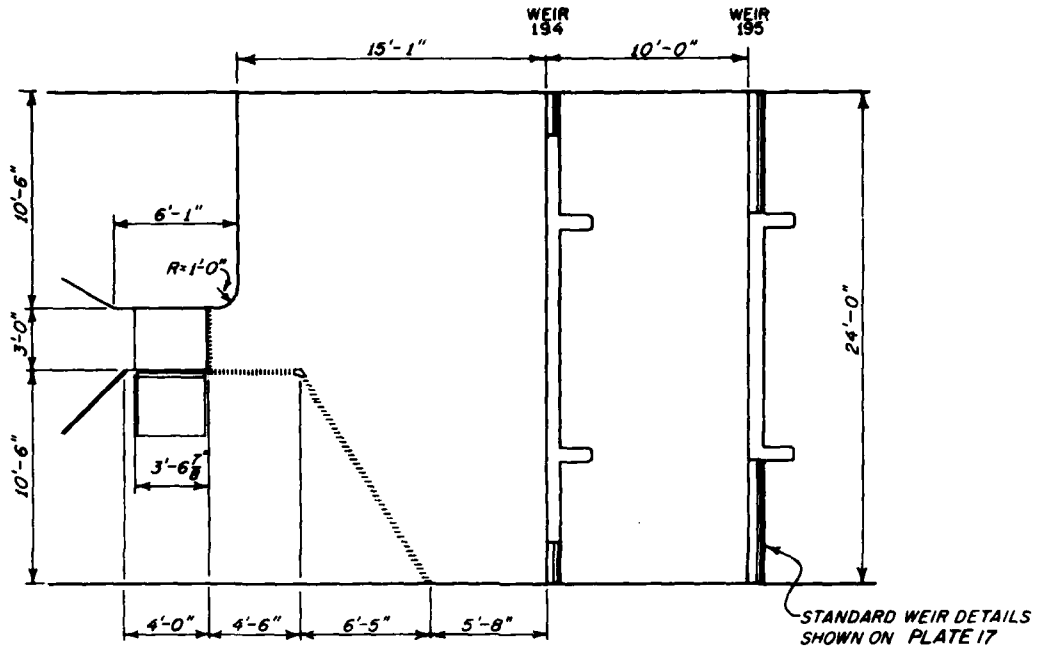
HEAD ON WEIR 248 12.0 INCHES
REGULATING SECTION DISCHARGE 200 CFS
DIFFUSER DISCHARGE 62.2 CFS
LADDER DISCHARGE 82.2 CFS

NOTES

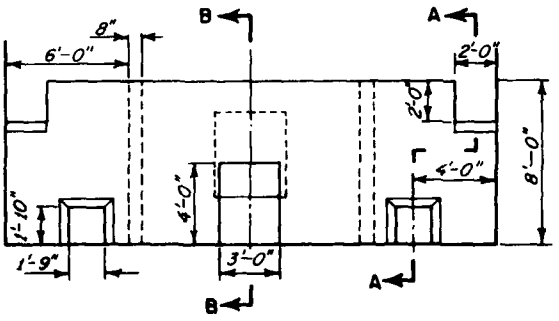
1 VELOCITIES MEASURED WITH MIDGET CURRENT METER, METER AXIS HORIZONTAL.
2 POOL AND BAFFLE DETAILS SHOWN ON PLATES 12 AND 30.

VELOCITIES
ENTRANCE AND EXIT POOLS
SLOT PLAN E
SOUTH SHORE FISH LADDER
FOREBAY ELEV 257

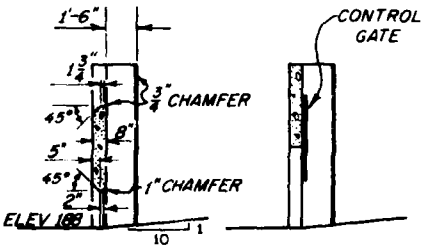
PLATE 32



PLAN



DOWNSTREAM ELEVATION



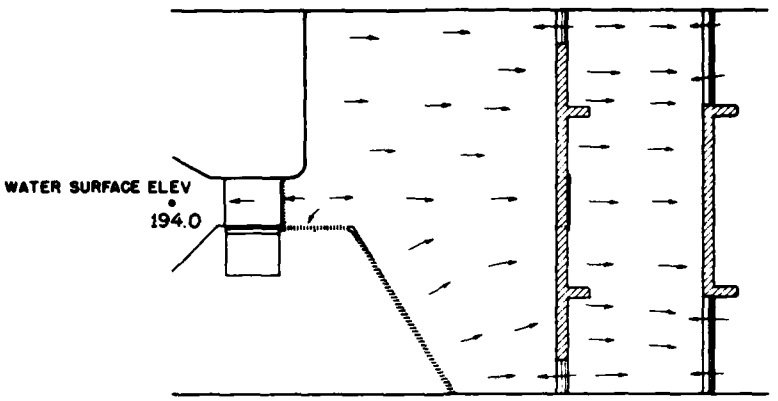
SECTION A-A

SECTION B-B

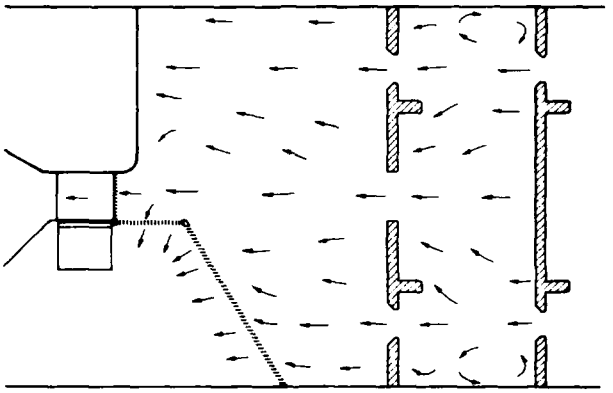
ORIGINAL WEIR 194

SOUTH SHORE FISH LADDER

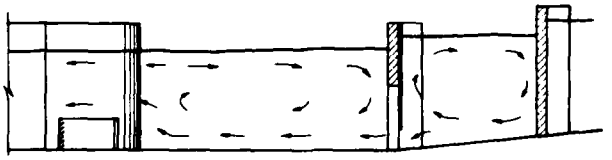
PLATE 33



1 FT BELOW WATER SURFACE



1 FT ABOVE FLOOR



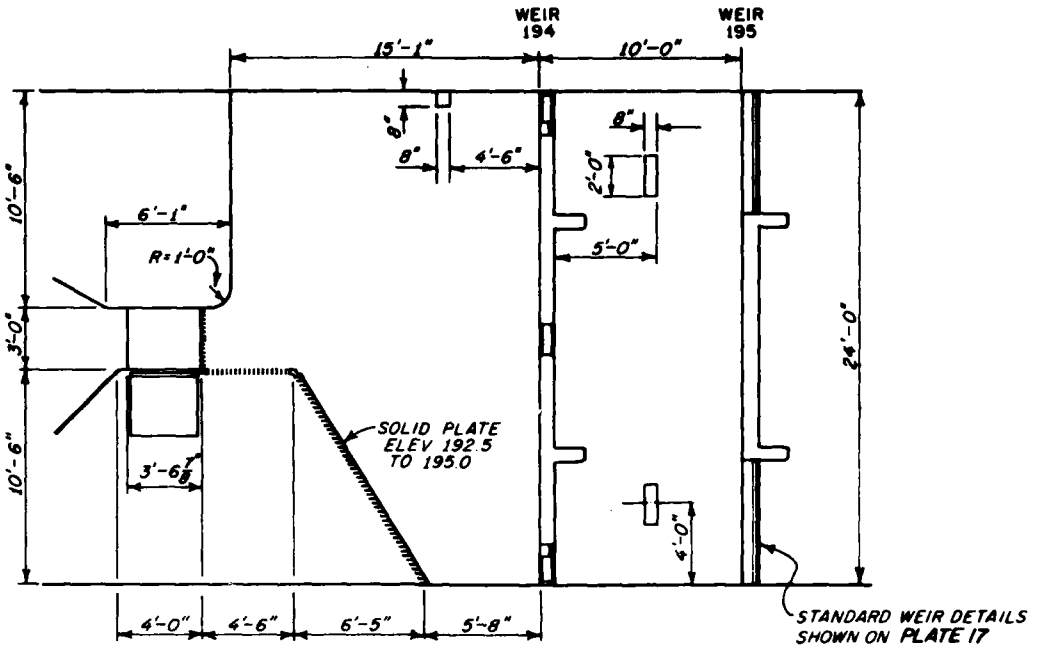
CENTER LINE OF LADDER

NOTES

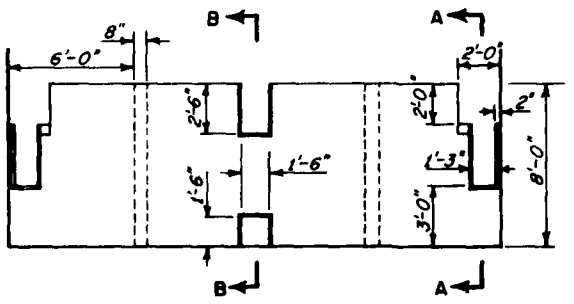
1. POOL AND WEIR DETAILS SHOWN ON PLATE 33.
2. HEAD ON WEIR 12 INCHES DISCHARGE 82.2 CFS.

FLOW DIRECTIONS
ORIGINAL WEIR 194
SOUTH SHORE FISH LADDER

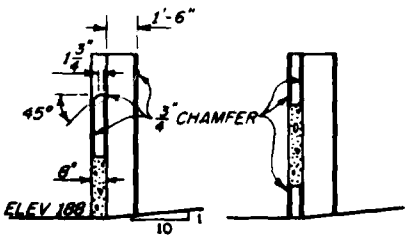
PLATE 34



PLAN



DOWNSTREAM ELEVATION



SECTION A-A

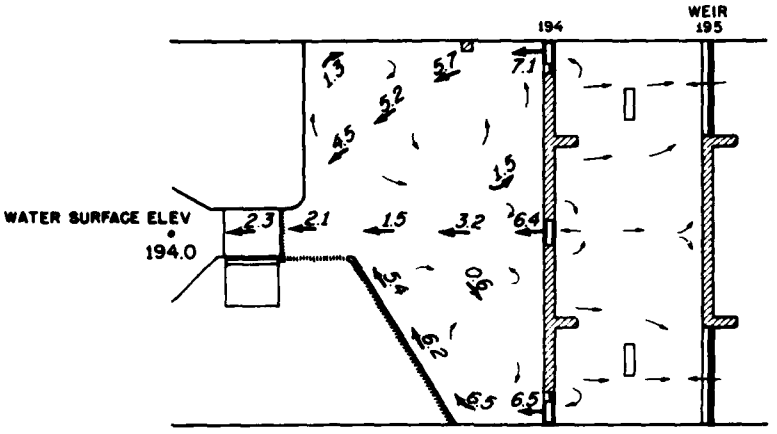
SECTION B-B

PLAN A

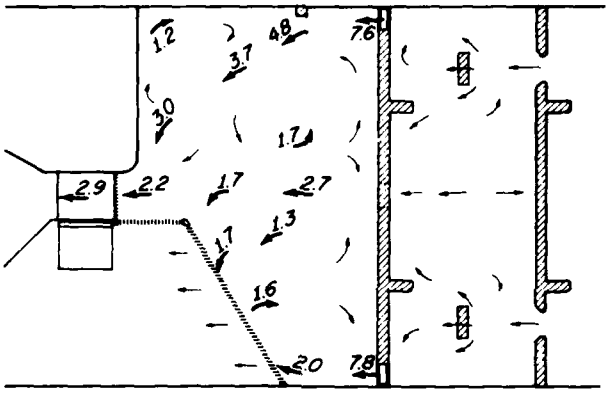
MODIFIED WEIR 194

SOUTH SHORE FISH LADDER

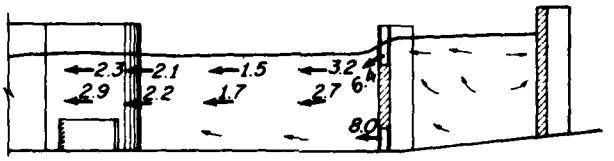
PLATE 35



1 FT BELOW WATER SURFACE



3 FT ABOVE FLOOR



CENTER LINE OF LADDER

NOTES

1. POOL AND WEIR DETAILS SHOWN ON PLATE 35.
2. HEAD ON WEIR 10 INCHES DISCHARGE 76.0 CFS.
3. VELOCITIES MEASURED WITH MIDGET CURRENT METER. METER AXIS HORIZONTAL.

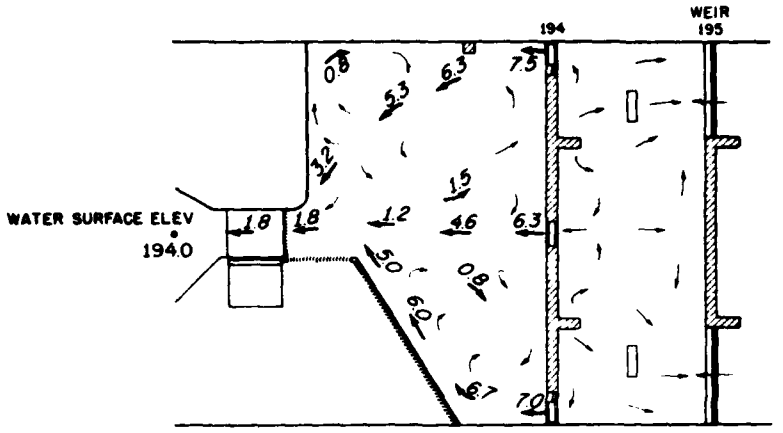
VELOCITIES

PLAN A MODIFIED WEIR 194

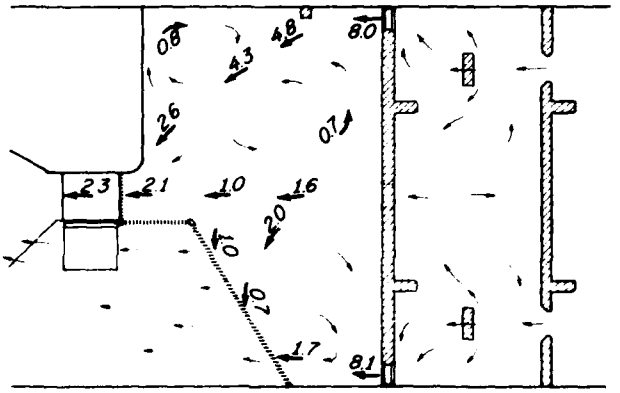
SOUTH SHORE FISH LADDER

10-INCH HEAD

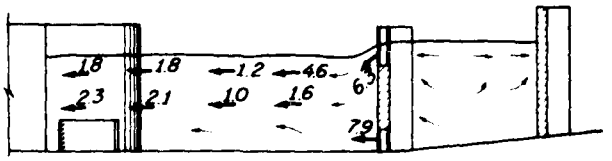
PLATE 36



1 FT BELOW WATER SURFACE



3 FT ABOVE FLOOR



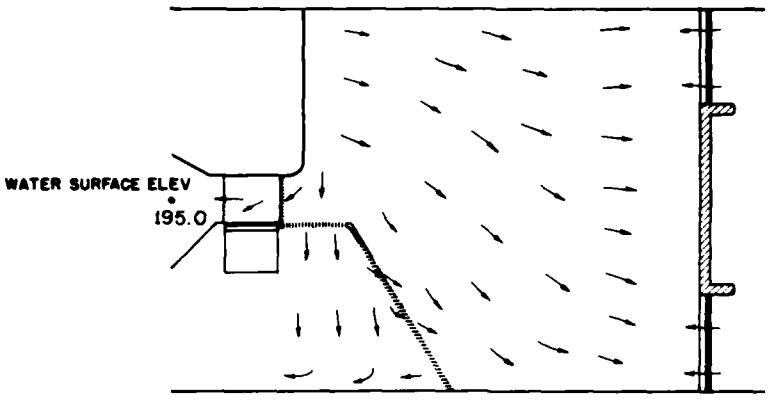
CENTER LINE OF LADDER

NOTES

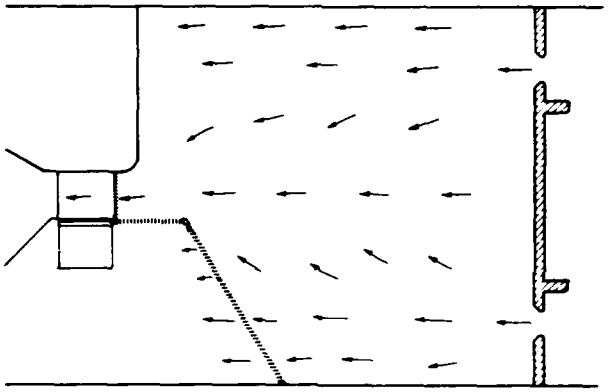
1. POOL AND WEIR DETAILS SHOWN ON PLATE 36.
2. HEAD ON WEIR 12 INCHES DISCHARGE 82.2 CFS.
3. VELOCITIES MEASURED WITH MIDGET CURRENT METER. METER AXIS HORIZONTAL

VELOCITIES
PLAN A MODIFIED WEIR 194
SOUTH SHORE FISH LADDER
12-INCH HEAD

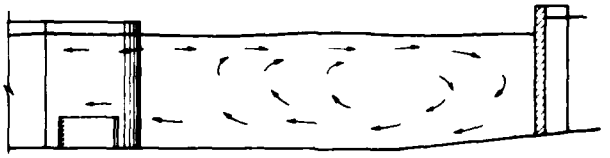
PLATE 37



1 FT BELOW WATER SURFACE



1 FT ABOVE FLOOR



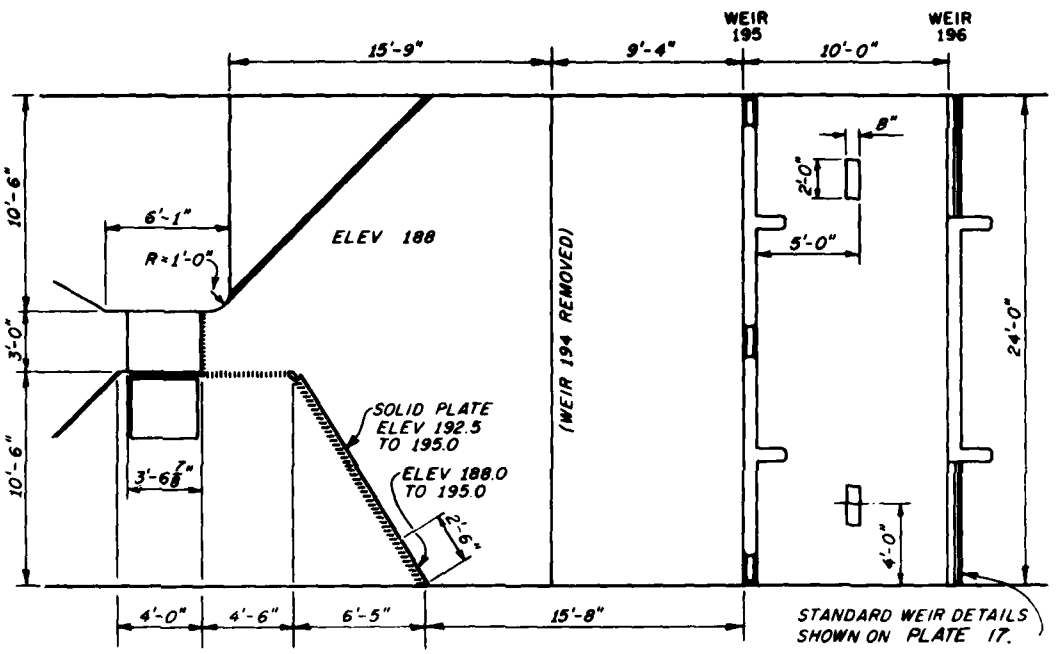
CENTER LINE OF LADDER

NOTES

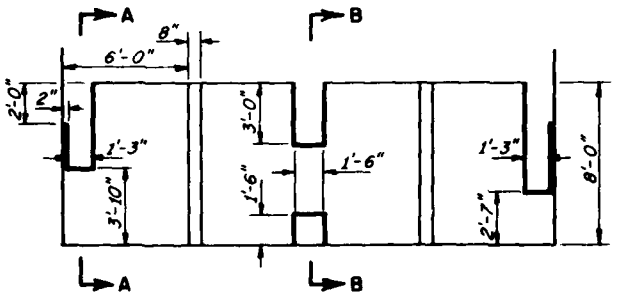
1. POOL AND WEIR DETAILS SHOWN ON PLATE 33.
2. HEAD ON WEIR 12 INCHES DISCHARGE 82 2 CFS.

FLOW DIRECTIONS
WEIR 194 REMOVED
SOUTH SHORE FISH LADDER

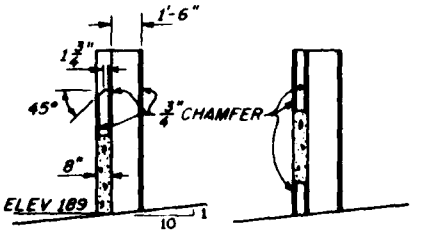
PLATE 38



PLAN



UPSTREAM ELEVATION



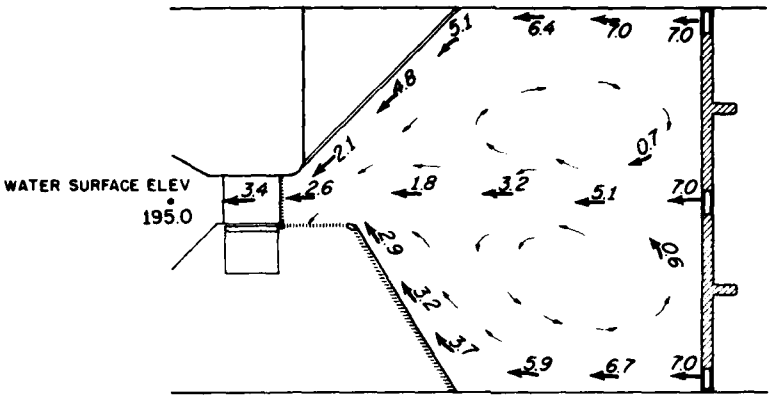
SECTION A-A

SECTION B-B

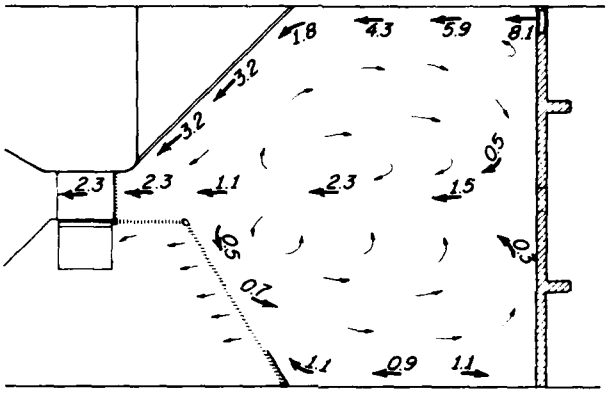
MODIFIED WEIR 195

SOUTH SHORE FISH LADDER

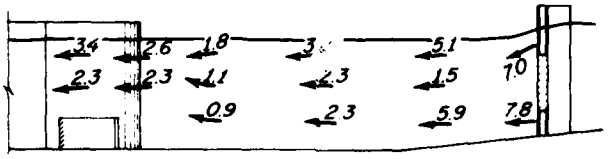
PLATE 39



1 FT BELOW WATER SURFACE



3 FT BELOW WATER SURFACE



CENTER LINE OF LADDER

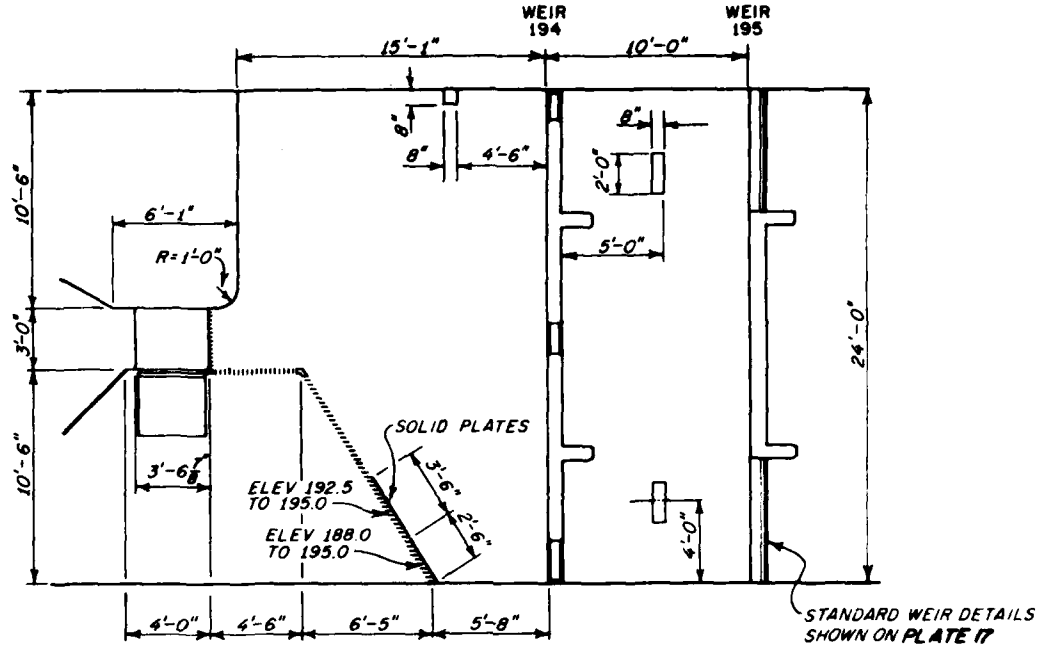
NOTES

1 POOL AND WEIR DETAILS SHOWN ON PLATE 39.

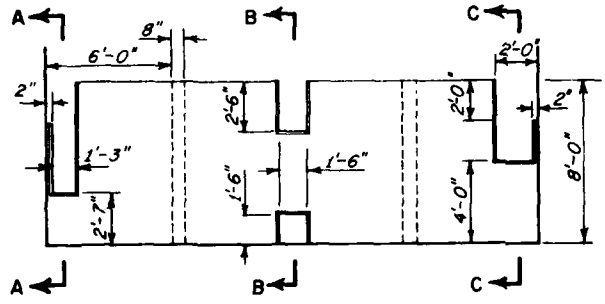
2 HEAD ON WEIR 12 INCHES DISCHARGE 82.2 CFS.

VELOCITIES
MODIFIED WEIR 195
SOUTH SHORE FISH LADDER

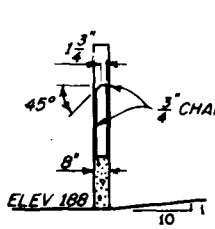
PLATE 40



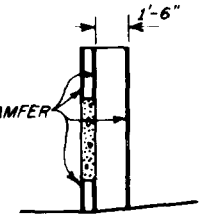
PLAN



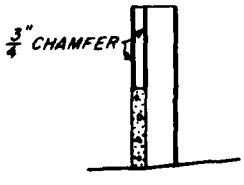
DOWNSTREAM ELEVATION



SECTION A-A



SECTION B-B

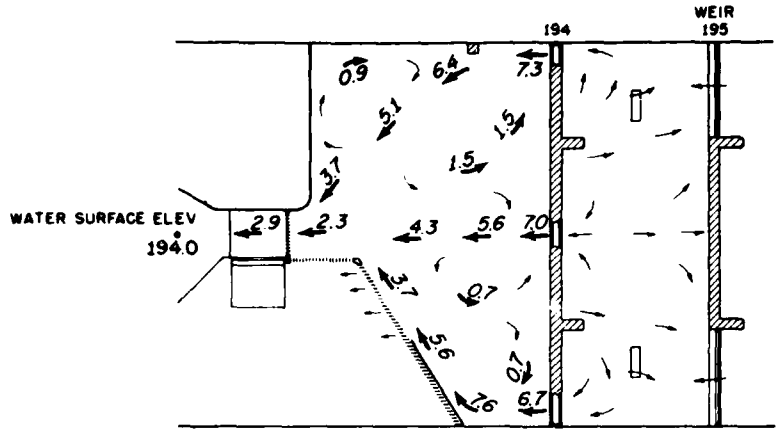


SECTION C-C

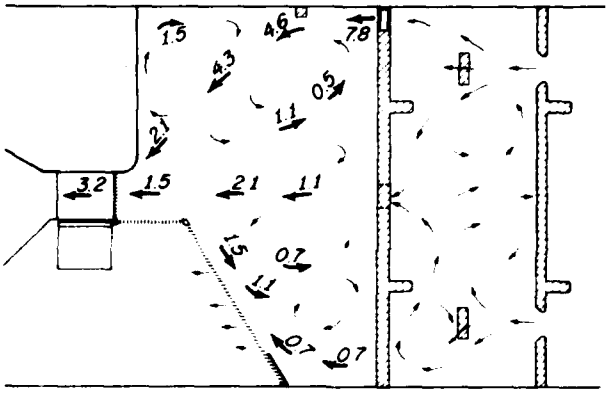
PLAN B

MODIFIED WEIR 194
SOUTH SHORE FISH LADDER

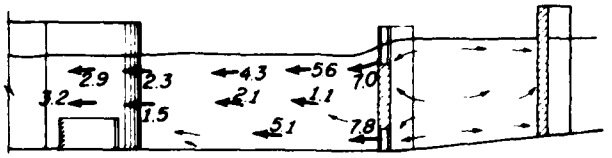
PLATE 41



1 FT BELOW WATER SURFACE



3 FT ABOVE FLOOR



CENTER LINE OF LADDER

NOTES

1. POOL AND WEIR DETAILS SHOWN ON PLATE 41.
2. HEAD ON WEIR 12 INCHES DISCHARGE 82 2 CFS.
3. VELOCITIES MEASURED WITH MIDGET CURRENT METER. METER AXIS HORIZONTAL.

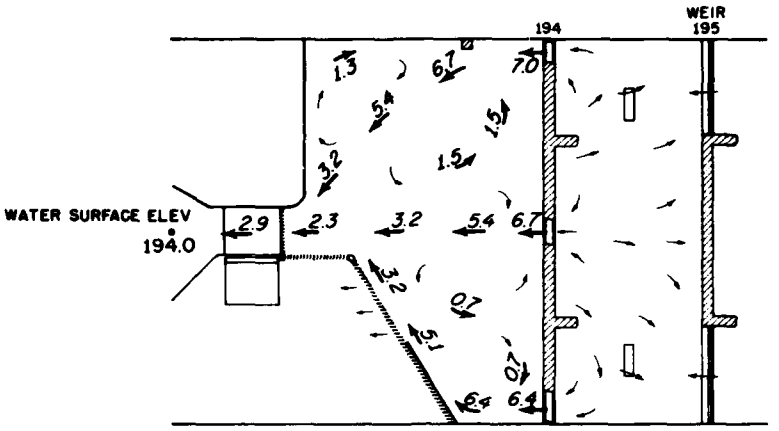
VELOCITIES

PLAN B MODIFIED WEIR 194

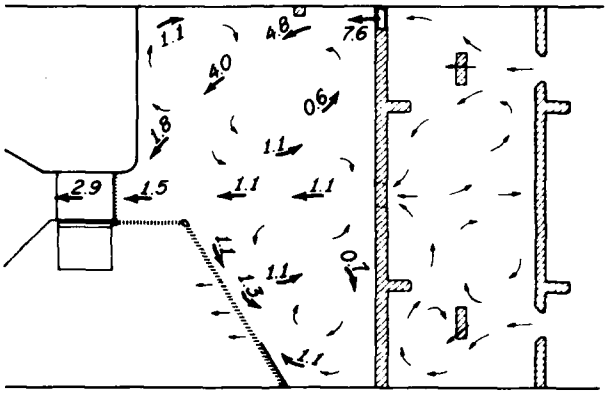
SOUTH SHORE FISH LADDER

12-INCH HEAD

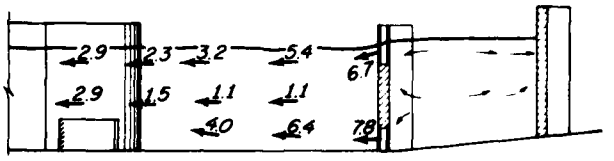
PLATE 42



1 FT BELOW WATER SURFACE



3 FT ABOVE FLOOR



CENTER LINE OF LADDER

NOTES

1. POOL AND WEIR DETAILS SHOWN ON PLATE 41.
2. HEAD ON WEIR 10 INCHES DISCHARGE 76.0 CFS.
3. VELOCITIES MEASURED WITH MIDGET CURRENT METER. METER AXIS HORIZONTAL.

VELOCITIES

PLAN B MODIFIED WEIR 194

SOUTH SHORE FISH LADDER

10-INCH HEAD

PLATE 43